THE
POPULAR SCIENCE
MONTHLY.

SEPTEMBER, 1902.

AREOGRAPHY.

By PERCIVAL LOWELL,

Vidi ego, quod fuerat quondam solidissima tellus
Esse fretum: vidi factas ex acquore terras;
Ovid, Metam, xv., 262.
"What once was solid ground I've seen to be a strait:
Lands I've seen made from out the sea."

HAD Ovid not let Pythagoras say this intentionally of the Earth he might be credited with having meant it for Mars. So startlingly apposite is its application to the history of Martian discovery. For the verse expresses to a presentment the course of man's acquaintance with that planet. A surface supposed at first partly land and sea; the land next seen to be seamed with straits; and lastly the sea made out to be land. Such is the history of the subject, and words could hardly have put the facts more neatly. 'Vidi ego, quod fuerat quondam solidissima tellus esse fretum' sounds like Schiaparelli's own announcement of the discovery of the canals. Indeed I venture to believe he would have made it had he chanced to remember the verse. 'Vidi factas ex acquore terras' certainly sums up what has since been found for the seas.

Three stages mark the course of Martian map-making from its beginning sixty-odd years ago to the present day. They constitute three epochs in the subject, which may be recognized distinctly in the chain of successive charts made of the surface of the planet from then till now. Such a series, however, is not for most people obtainable. Only to specialists is the evidence for or against any scientific belief present at any time in its entirety. Not only has the new evidence not had time to filter through the usual channels into general absorption, but

the old too has often remained either unknown or ignored, buried in the books which nobody reads. Thus the whole chain of argument is rarely available to those not engaged in the investigation, and the conclusions reached appear to hang on slenderer threads than is really the case. It has seemed to me, therefore, not without profit to collect into one the various views of the cartography of Mars, so much, that is, as is essentially original and not mainly confirmative of the work of previous observers. To this intent, I have produced the new maps, reproduced the old and set them opposite one another. Thus brought face to face they make a rather impressive self-confessed avowal of relationship.

Twelve maps constitute the series. Each marks the point areography had reached at the time. No map has been left out which added anything new except when a contemporary added more. The twelve maps arranged in chronological order are these:

I.	Beer and Mädler,	1840.
II.	Kaiser,	1864.
III.	Dawes by Proctor,	1867.
IV.	Résumé by Flammarion of all to date,	1876.
V.	Schiaparelli,	1877.
VI.	"	1879.
VII.	"	1882.
VIII.	"	1884.
IX.	Lowell,	1894.
X.	"	1897.
XI.	"	1899.
XII.	"	1901.

As is commonly the case when things are summed up, much more results than one anticipates. It always turns out that one has spent more than he imagines; and fortunately with accumulations it is sometimes the same. Much emerges thus from the present assemblage and three points in particular stand out to command attention. The three points will be found to be:

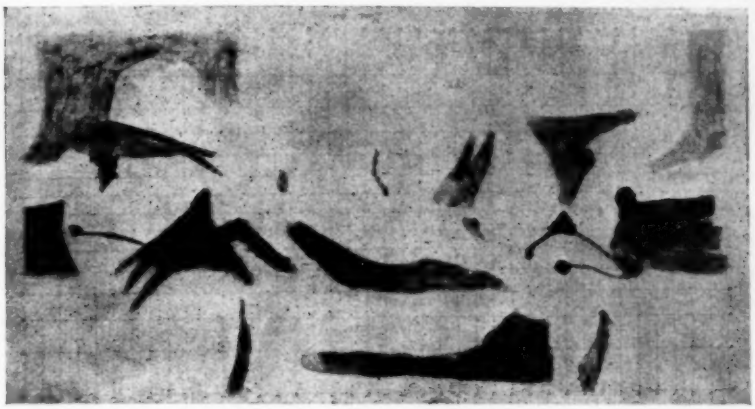
1. The fundamental agreement of the whole series.

2. Evidence that the peculiarity of the markings seen by Schiaparelli was not the fathering of fancy, but a recognition forced upon him by the markings themselves.

3. A visible evolution in discovery which has steadily progressed from the beginning to the present day marked by three stages—pre-Schiaparellian, Schiaparellian and what we have learned since.

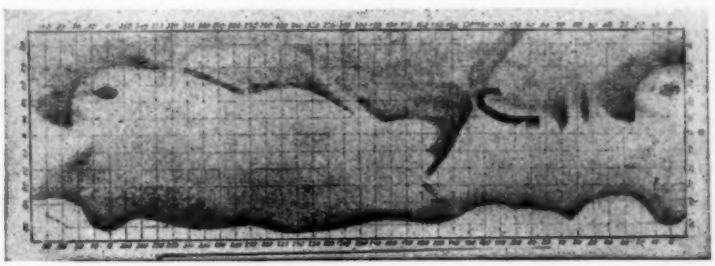
To be struck by these three deductions it is only necessary to compare the several maps with one another when one shall have learnt so much of the circumstances of each as to make their relations understandable.

The first map ever constructed of Mars was drawn by Beer and Mädler in the fortieth year of the last century, and is here numbered I. The observations upon which it was based were made with a four-inch telescope and extended in all over eight years. In this map all the main features which we note to-day are unmistakably depicted. The 'Eye of Mars' (the Lake of the Sun) is well seen, as well as the



MAP 1. BEER AND MADLER, 1810

dark marking that makes eyebrow to it on the south. Next come the Mare Sirenum and the Mare Cimmerium as one long leech-like patch, duly inclined to the parallels. Then follows the Syrtis Major, the first discerned of all the markings on the planet. It was drawn by Huyghens in 1659. Out of it is delineated the Icarium Mare, ending unmistakably in the Sabæus Sinus seen as a scroll. Dark patches to the south

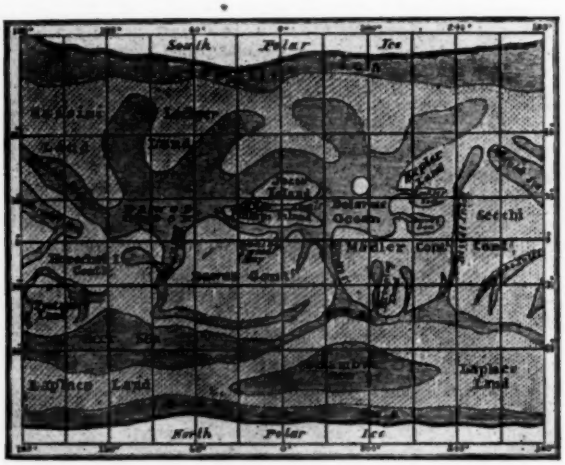


MAP 2. KAISER, 1864.

stand for the Mare Erythræum and sporadic ones in the midst of the great continental areas north give adumbration of the canals and oases later to be discovered there.

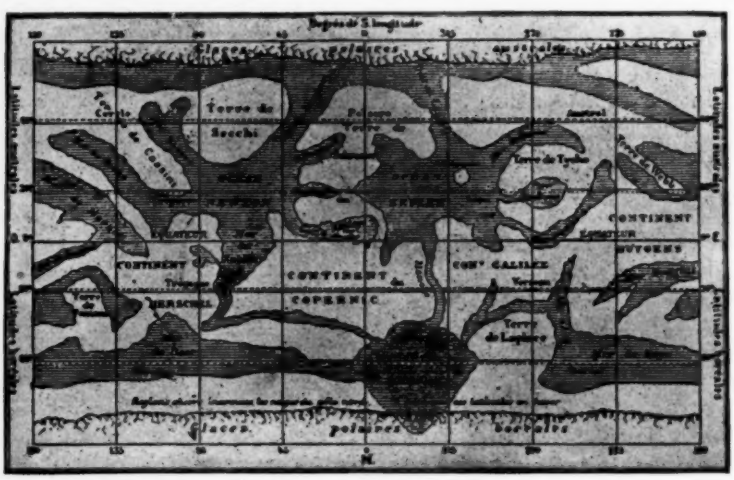
The next map, No. II., is Kaiser's, made in 1864. In it it is easy to trace all the fundamental features we have noted in the chart of

Beer and Mädler: the Eye, the Maria, the Syrtis Major, the Sabæus Sinus. In general they perfectly reproduce their prototypes, while in detail they present a little more closely the appearance of the same



MAP 3. DAWES BY PROCTOR, 1867.

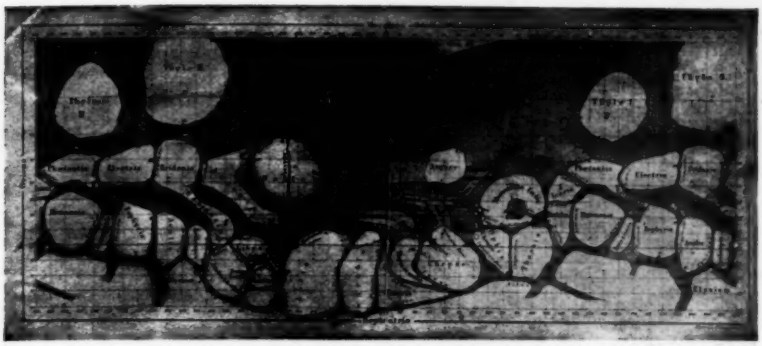
markings to-day. The map is a slight advance upon its predecessor, and a complete corroboration of it. In these portraitures Kaiser stood not alone. About the same date Lockyer, although he constructed



MAP 4. RÉSUMÉ BY FLAMMARION OF ALL TO DATE, 1876.

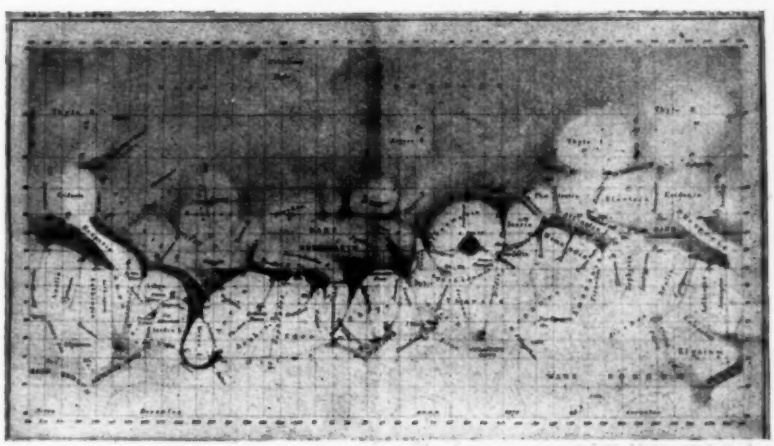
no map, made some excellent drawings quite confirmative of Kaiser's and rather better. So also did Dawes (Map III.), nicknamed the eagle-eyed for his ability to detect difficult phenomena.

Schiaparelli opened a new era in 1877 (Map V.). Unsuspicious of what he was to stumble on, he seized the then favorable opposition to make, as he put it, a geodetic survey of the planet's surface. He hoped to find this undertaking feasible to the accuracy of micrometric measurement. His hopes did not belie him. He found that it was



MAP 5. SCHIAPARELLI, 1877.

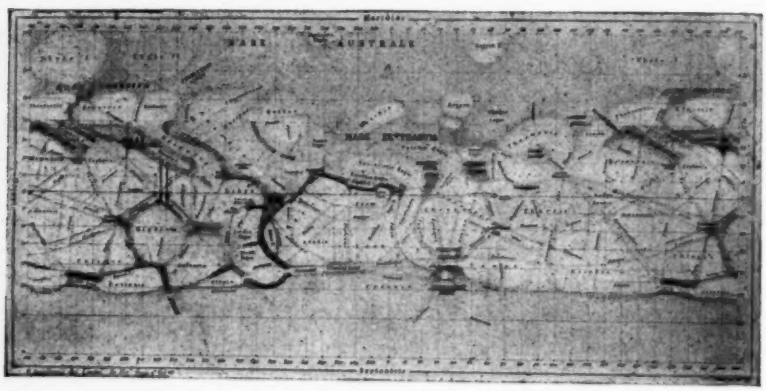
possible to measure his positions with sufficient exactness to make a skeleton map on which to embody the markings in detail—and thus to give his map vertebrate support. But in the course of his work he became aware of hitherto unrecognized traits of the so-called continents.



MAP 6. SCHIAPARELLI, 1879.

Instead of displaying a broad unity of face the bright areas appeared to be but groundwork for streaks. The streaks traversed them in all directions, tessellating the continents into a tilework of islands. Such mosaic was not only new, but the fashion of the thing was of a new order or kind. The old markings were patches which might well

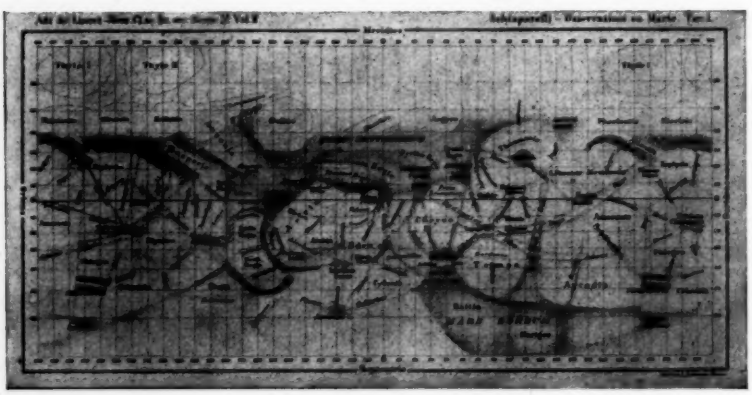
enough be seas and oceans, but here were narrow bands which could hardly pass muster as straits, so long and narrow were the arms thus thrust out into the continents by the seas. Straits, however, Schiaparelli considered them and gave them the name canali, or channels.



MAP 7. SCHIAPARELLI, 1882.

How unfamiliar and seemingly impossible the new detail was is best evidenced by the prompt and unanimous disbelief with which it was met.

I have spoken of Dawes as draughting some of these lines; but it must not be supposed that he did more than adumbrate them. It is



MAP 8. SCHIAPARELLI, 1884.

possible now to recognize in what Dawes saw, glimpses of something which later Schiaparelli observed, but it would be quite erroneous to imagine such suggestions as in any sense forestalling a view of the things themselves. Perhaps the best proof of such insufficiency is that

Schiaparelli himself was the only person who perceived any relationship between the two, and that after the fact.

Unmoved by the universal scepticism which rewarded his epoch-making discovery, Schiaparelli went on, in the judgment of his critics, from bad to worse—for in 1879 (Map VI.) he took up again his scrutiny of the planet to the detecting of yet further peculiarity. He re-observed most of his old canals and discovered half as many more. But the striking part of the affair is something which does not seem to have attracted attention—the increased unnatural look of his lines. Lost in the general incredulity a little bizarreness more or less escaped significant criticism. It was all so strange that any change in strangeness simply went to confirm the universal skepticism.

In 1881–2 (Map VII.) he attacked the planet again and with results yet farther out of the common. His lines were still there with more beside, but the startling thing about them was their appearance. If they had looked strange before, they now appeared positively unnatural. The things were simply fine, narrow, uniform, straight lines sometimes alone, sometimes astoundingly paired, but, however associated, geometrical to a degree. As he himself expressed it, they seemed as if drawn by rule and compass, these absolutely regular lines connecting one dark marking with another.

In 1883–4 (Map VIII.) the same thing occurred. An unnatural precision distinguished all his 'canali.' To add to the difficulty of acceptance, as in 1882, they followed arcs of great circles, and were in every respect markings of a highly suspicious cast of character. Nor did his exclusive perception of them conduce in astronomic estimation to the assurance of their objective existence.

The map compiled from the observations of 1883–4 was the last made by Schiaparelli of the whole planet. In subsequent oppositions the south pole was so tilted away from the earth that only the regions of the northern hemisphere were well seen and in consequence charted. But the omissions are not material to the present purpose, for the character of the charting remains substantially the same.

As will have been gathered from the above description, the factitious appearance of the 'canals' was the chief bar to their acceptance. That they looked inconceivable argued their conception in the brain of the observer alone. An inference, this, not without a certain justification in the inability of others to follow in his steps. But one point contained in the charts failed of making its impression. If we compare with special reference to the unnaturalness of the lines the several maps of the series with one another we shall be aware of a progressive increase in regularity in the physiognomy of the canals with the time. Schiaparelli's map of 1877 viewed in the light of his subsequent productions seems but a tame bit of innovation after all. His canals as he saw them

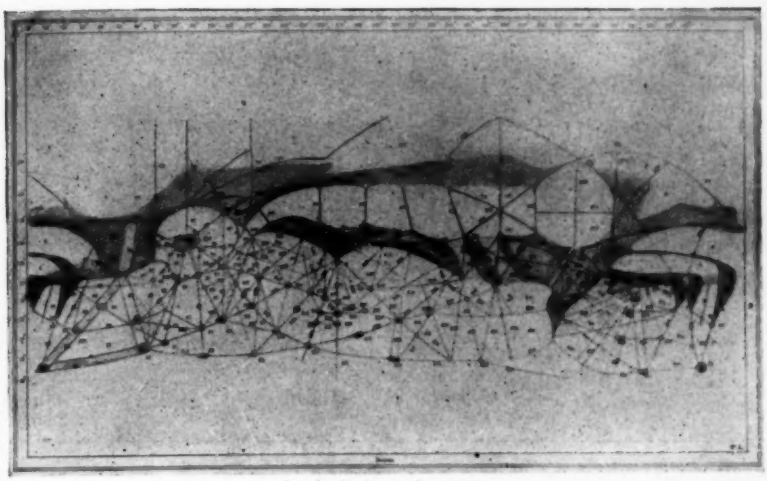
then were narrow winding streaks, hardly even roughly regular and by no means such departures from plausibility as to be without the scientific expurgatorial pale. Indeed to a modern reader prepared beforehand for geometric construction they will probably appear no 'canals' at all.

Certainly the price of acceptance was not a large one to pay. But like that of the Sybilline books it increased with putting off. What he offered the public in 1879 was much more dearly to be bought. The lines were straighter, narrower and in every way less natural than they had seemed two years before. They were again refused belief and on seemingly better grounds. In 1881–2 they progressed still more in unaccountability. They had now become regular rule and compass lines as straight, as even and as precise as any draughtsman could wish and quite what astronomic faith did not desire. Having thus donned the character, they nevermore put it off. Their precision grew persistent until finally other men began to admit what on much easier terms they had earlier rejected.

Now this curious evolution in design points to one interesting deduction. It shows that Schiaparelli started with no preconceived idea on the subject. On the contrary it is clear that he shared to begin with the prevailing hesitancy to accept anything out of the ordinary. Nor did he overcome his reluctance except as by degrees he was compelled, for the canals did not change their characteristics nor could the glimpse he got of them have altered as time went on, except in frequency, so far as the eye itself was concerned. But the brain made different account of the reports as it grew familiar with the messages sent it, and gradually by acquaintance learned to distinguish more particularly what it saw. In other words, the geometrical character of the 'canals' was forced upon him by the things themselves instead of being, as his critics took for granted, foisted on them by him. We have since seen the regularity of the canals so undeniably that we are not now in need of such inferential support to help us to the truth, but too late, as it is, to be of controversial moment the deduction is none the less of some historic force.

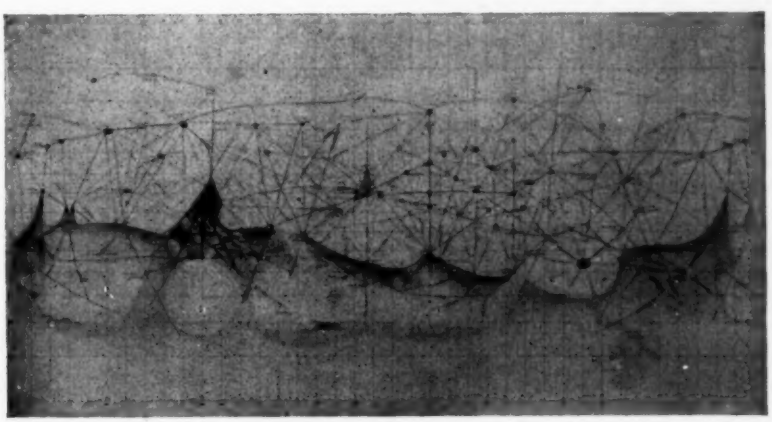
The year 1890 brought Schiaparelli's labors to a close; and 1892 ushered in at once a new cycle of the planet's seasons and a fresh set of observers on earth. In 1892 the planet was again favorably placed for observation, much as it had been in 1877, and the chief observers of it were W. H. Pickering at Arequipa, Peru, and Schaeberle and Barnard at the Lick Observatory, California. Just as Dawes had made in some sort a transition between the first period and the second, so these observers furnished the stepping stone from the second period to the third. W. H. Pickering detected in the planet's dark regions certain yet darker ramifications which he denominated river-systems. Nearly simul-

taneously the Lick observers noted what they called streaks in the same regions. These markings were as their names imply irregular or indeterminate. Nor were they credited by their discoverers with



MAP 9. LOWELL, 1894.

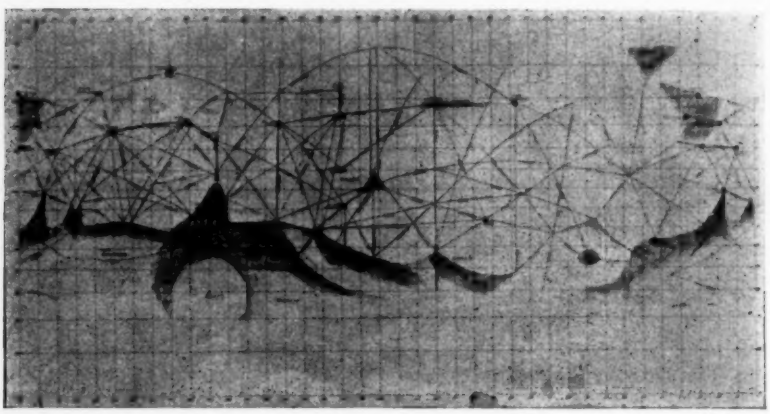
significance beyond what the names import. They were thus of the same transition character as Dawes' delineations. But Pickering drew some important inferences from what he saw. From what he detected



MAP 10. LOWELL, 1897.

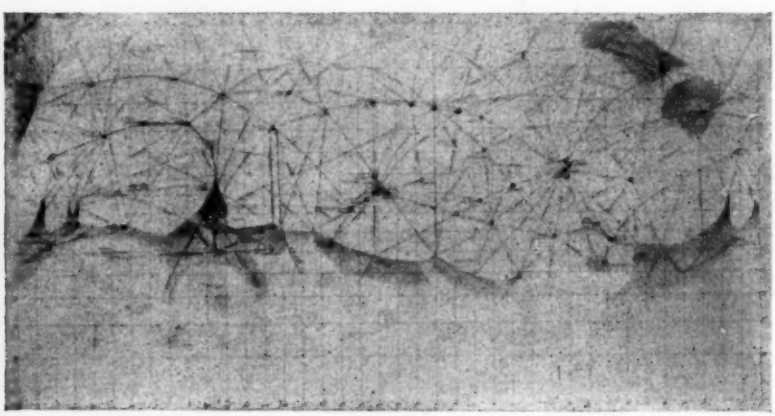
he concluded that the greater part of these dark areas could not be seas as they had been supposed to be even by Schiaparelli. Schaeberle and Barnard on this and on other grounds advanced something of the same theory.

In 1894 (Map IX.) Douglass at Flagstaff discovered a fact which did for the dark regions what Schiaparelli's canals had done for the light ones. He found on scrutinizing the southern dark areas that Pickering's river-systems, which he too had seen in 1892, came out



MAP 11. LOWELL, 1899.

again and proved to be but part and parcel of a systematic set of lines networking those areas. He noted that these lines were not only simple streaks, but that they had nothing irregular about them, and could not possibly, therefore, be the river-systems supposed by Pickering. The lines were straight, equable in width and connected with one another at



MAP 12. LOWELL, 1901.

certain determinate points. They followed apparently arcs of great circles and covered all the dark regions which could be well seen with a singularly symmetric mesh. In other words, they presented all those strange, peculiar and enigmatic characteristics which distinguished the

so-called canals, and rendered them unlike anything else in heaven and earth. Here was a fact of the utmost significance. The curious canal system was not confined to the bright regions of the planet. The dark regions, too, had a canal constitution as intricate and as complete as theirs and its perfect parallel.

It is interesting to note that the dawning recognition of these canals followed the same course that it had with the others. Both sets were perceived as streaks and sinuousities before their strangely regular character flashed upon the observer.

As time went on it became evident that the two sets of canals formed part of one whole. The mesh in the bright regions ended at points on the so-called coast-line where the mesh in the dark regions began. The system was thus knit together and made of a piece over the whole surface of the planet. On the belt of narrow 'seas' lying between the continent and the chain of islands to the south, it was as of a lacing run through eyelets in the coast-lines giving an effect of slashed trunk-hose, so singularly did the canals criss-cross them working up in a zigzag progression from one end of a sea to the other.

In 1896-7 (Map X.) the dark region canals came out still more distinctly and especially the oases or spots at their junctions.

At the succeeding oppositions they continued visible and the few dark areas in the northern hemisphere were found in 1899 (Map XI.) and still more so in 1901 (Map. XII.) to be similarly but groundwork for a superposed mesh of knots and netting. No part of the somber portions any more than of the light ones remained free of the systematic triangulation.

Furthermore each period contains within itself a progressive development in particularity. Each successive opposition has made the foundation it found more secure and added a superstructure of its own. And what has been true of each period by itself has been equally so of the three taken together. As the maps show, each has been at once a review and an advance. This has been due not only to increased optical facilities and improved atmospheric conditions, but still more to systematic, persistent and extended work on the part of the observers.

It will thus be seen that three stages mark the advance in areography from the time of Beer and Mädler to the present day and that these stages are distinguished by the detection of essentially new and fundamental phenomena:

I. Stage of supposed continents and seas.
II. Stage of ' canals ' found intersecting the lands.
III. Stage of ' canals ' found traversing the ' seas.'

Each of the stages is here represented by four maps, and each is an advance upon its predecessor.

UNIVERSITY CONTROL.

By Professor J. J. STEVENSON,
NEW YORK UNIVERSITY.

THE pessimism with which some recent writers regard the university outlook in our country is, unfortunately, not wholly unreasonable. Yet the conditions, far though they be from the ideal, are not such as to make one despondent. The rapid development of our country has brought difficulties to colleges and universities as it did to business enterprises. The business world recognized the difficulties and overcame them at the cost of complete change in methods. Let the business common sense, which has made the United States preeminent in commerce, be applied to university matters and it will give us equal preeminence in education. It is necessary to recognize the conditions frankly, to cast aside injurious makeshifts and to adjust the methods to the new surroundings and the new demands. For the surroundings and the demands are new. Within the last thirty years, the relations between the teaching and the corporate boards have undergone a serious transformation; the relations of college professors to the community, as well as to their students, have been revolutionized; the manner and the matter of the professor's work in many departments bear no resemblance to those of thirty years ago. The extent and nature of these changes are known in but slight degree to those in the corporate boards of colleges and universities; the community is wholly ignorant of them. Let us understand them.

At the close of the Civil War, American colleges were comparatively small. Their trustees, for the most part, were alumni or professional men familiar with college work, as it then existed, and personally acquainted with the professors with whom they were in sympathy and for whose benefit they held their place. But, within a generation, the small colleges have become large, many of them have expanded into true universities with numerous departments, hundreds of instructors and thousands of students; while the financial interests, expanding more rapidly than the institutions, have attained a magnitude in some cases as great as that of New York's finances fifty years ago. No trustee in a large college to-day can know much of college work as such, can be acquainted with the faculties, can do much more than bear his share of the business responsibility. Vast sums of money needed for expansion, even for continued existence, are sought from men, who, having

accumulated wealth, desire to leave the world better than they found it. Such men, in many cases, hesitate to entrust the disposition of their gifts wholly to others and each year finds them in increasing numbers upon corporate boards of colleges and universities—sometimes because they have contributed, sometimes because it is hoped that they will contribute.

These patrons, if not college graduates, labor under a disadvantage in that they are unacquainted with the nature of the work for which colleges have been founded; even if they be college graduates they are at an almost equal disadvantage, as absorption in business or professional pursuits has prevented them from keeping track of the changes which have come about since their graduation. As a rule, their new responsibility does not tend to create or to renew acquaintance with college work; the trustees' duties usually begin and end with labors on committees, so that naturally enough the business affairs with which they have to do become for them the all-important work of the institution. And this conception is strengthened by thoughtless assertions of men who ought to know better. Only recently this community was informed that the millionaires make the universities. With such flattery ringing in their ears, one is not surprised that some trustees forget the object for which the university exists and think of professors, when they think of them at all, as merely employees of the corporation, whose personality and opinions are as unimportant as those of a bank clerk.

Unacquainted with the faculty, unfamiliar with the extent and even character of the work done by individual professors, the trustees depend for knowledge of the educational affairs upon reports by the college or university president, for in rare instances only have faculties, as such, representatives in the board. Unfortunately, very few of our college presidents have taken a preliminary course to qualify them for the position. Indeed, it must be confessed that ability to superintend educational work has not been regarded in all cases as the essential prerequisite; in some cases that appears to have been thought less important than a supposed ability to collect money. But at the best no one man is able now to understand all the phases of university or even college work, as many college presidents already recognize; but were he able and willing, he has little opportunity to make his trustees comprehend them. Discussion of purely business matters occupies so much attention during board meetings that discussion of other matters must be deferred and the president's report is printed that it may be read at leisure. The best of presidents becomes weakened by the overwhelming importance of the financial side and comes to look upon increasing numbers as the sure proof of success. He soon finds himself between the upper millstone of the trustees and the nether millstone of the faculty, the former insisting upon numbers, the latter upon a high

standard, so that in an honest effort to perform his duty, he is in danger of receiving censure from both.

The change in relations of the educational and corporate boards is due to a drifting apart of the two boards, leading to the loss of that sympathy, which was the bond, and to a reversal of the relative importance of the boards. Formerly trustees existed to care for the faculties; now many trustees evidently feel that the faculties are appendages to the board of trustees.

But while the conditions in respect to the relations between educational and corporate boards have undergone a change, on the whole, decidedly for the worse, the conditions in respect to the professor's relations to the community and to his work have undergone a change no less radical, not indeed for the worse, but at a cost to himself so serious as to impair his usefulness and to threaten that of the institutions themselves. Here lies, in the opinion of many thoughtful men, the secret of deterioration observable in the output.

The common belief is that the college professor's teaching work is purely incidental, an easy method of obtaining a good living, that he may pursue his studies without anxiety respecting worldly matters. Whatever may have been the case in some prehistoric period, it is certain that in our day there is no calling in which the pecuniary compensation is so low, while the intellectual requirement is so high as in that of college professor. The average salary of college men in New York city is much less than the average salary of clergymen. The expansion, one may almost say the very existence, of American colleges is due to the consecrated devotion of those who give the instruction. Of the immense gifts made to American colleges, comparatively little goes toward increasing salaries of professors already at work; almost the whole goes to meet the insatiable demand for expansion.

Nor is the college instructor a man of ' abundant literary leisure, as many still suppose. College professors of a generation and a half ago were, for the most part, recluses—made so by the nature of the studies then included in the college curriculum. The hours of teaching were short, and beyond those the institution demanded little. There was abundant leisure and it was used well in study. But now, in many departments the hours are long, often covering in one way or another the whole day, while other requirements are severe. The college demands that the professors be encyclopedic in knowledge of the subjects covered by their chairs; no matter how broad these may be, that they contribute frequently to the journals, that they be prominent in social, scientific, political or religious affairs. How much of the literary leisure remains in some departments one may imagine—and the increasing requirements, all involving pecuniary expenditure, have come with decreasing salaries. For the most part, professors are no longer doctri-

naires; the character of their work compels close contact with the world. Museums of applied chemistry, physics, biology and geology are notable features in all the larger universities and are not unknown in the smaller institutions. Social science and psychology no longer deal in merely *à priori* discussions; they deal with facts for which search is made everywhere.

But far more important is the change in the professor's relation to his work. And here reference may be made parenthetically to a matter of some importance. The college curriculum of forty years ago was, to say the least, elementary. A reasonably good graduate was fit to be tutor in any branch and a professional man, who had kept up his literary tastes was not thought to be presumptuous when he applied for any one of the chairs. The college president was usually professor of mental and moral science, because a clergyman of rather more than average ability was, of course, fitted for that chair. But in this day, special, prolonged preparation is required for any chair, be it philosophy, history or chemistry. The progress which this condition indicates has led to an unforeseen difficulty which is becoming a subject of anxiety. For a long period the college curriculum, framed on narrow lines, remained practically unchanged and the secondary schools, with small equipment, prepared pupils in a leisurely way. As a rule the preparation was good and the boys entered college practically on a level. Within twenty years our colleges have not only increased the entrance requirements for some parts of the old course, but they have introduced new courses, even new departments, each with special entrance requirements, often very high. In great part, the secondary schools, with their limited resources, have been unable to increase their staff so as to keep pace with increasing demands from the colleges, and the students from different schools, though nominally alike in sum of preparatory work, are no longer approximately on the same plane. The college instructor, who has to do with the earlier years, finds himself burdened not merely with the work legitimately belonging to him, but also with much of the preliminary training. This combination of preparatory drill and advanced work is perplexing.

It is very true that the burden of changed conditions in respect to college work is not felt equally in all departments. Professors in charge of some of the older chairs have an increased burden, in that the method of teaching differs, yet, taken as a whole, matters, in so far as undergraduate work is concerned, remain with them pretty much as they were thirty years ago. But the teaching of concrete subjects is so completely changed both in matter and manner that one must dwell somewhat in detail upon the conditions; the more so because they have come about so rapidly that even professors in other departments are unaware of their extent.

Science, for a long time, was an insignificant feature of the college curriculum; its treatment was more elementary than that of history. The professor had an immense field to cover—the whole of nature aside from man's achievements in a few directions—but, while he taught many subjects after a fashion, he studied only one. The stock of knowledge was very small and anything new to one observer was likely to be new to all others. Investigation was a simple matter; ingenuity, industry and keen discrimination made up most of the necessary equipment; so that there were few earnest teachers who failed to contribute frequently to the common stock. But, by their earnestness, these men worked their destruction as investigators; for while each had his chosen field of study, he still covered the whole area as teacher. Many of the discoveries made by these men were startling and were discusssed in a more or less inaccurate way by the newspapers. Students sought explanation from the professor who was supposed to know everything. The botanist was puzzled by questions respecting chemical physics or psychology; the physicist was worried by questions respecting alleged discoveries in biology or geology. Practical application of newly discovered principles followed quickly to add to the teacher's trials. There was no longer time for special investigations and all one's energies had to be devoted to a vain effort to keep pace with investigations in the several directions.

The danger of this condition was recognized early in some of the older and wealthier institutions, so that in them, as in some of the newly organized and well-endowed universities, the fact was accepted that the several sciences were soon to be independent professions, and the departments of chemistry, physics, biology, psychology, geology, paleontology and mineralogy became practically schools, each with its own staff of professors and assistants.

But in too many of our colleges the danger was not recognized at an early period and in too many it is still unrecognized. Only a few of our institutions have more than four chairs in natural science, many have only two, and far too many are still in the sub-high school stage of only one. Yet the catalogues of such institutions offer a long series of courses, graduate as well as undergraduate, in several departments. A rather prominent college trustee not long ago informed the writer that a professorship of psychology or physics or geology is hardly equal in extent to one of Latin or pure mathematics. Yet any one of the chairs first named covers a group of subjects as unrelated as those embraced by the old-time chair of 'mental and moral science, history and belles lettres.' It is broader in scope than that other chair of 'ancient and modern languages' which existed in many colleges thirty-three years ago. A professor who teaches three branches of chemistry, physics or geology in three successive hours deals with three wholly

different matters, three distinctly unrelated lines of investigation, requiring independent methods of preparation and each demanding as much knowledge as does the whole work of a professor holding a chair of languages. But, aside from this class-room labor, the teacher of science in the average institution must prepare demonstrative lectures, must keep apparatus in proper condition, must procure and care for museum material, must spend time with classes in field demonstration, while, in addition, he has the never-ending grind required to keep him in touch with the growth of knowledge respecting subjects embraced in his department. These are burdens from which professors in the older courses are happily free.

It is true that the science teacher in most of our colleges has only himself to blame for the severity of his burden. Determination to give to his students what he believes due to them has led him to make exertions which were not required but which, once begun, came to be regarded as part of his duties. Had he not manufactured apparatus and begged money with which to procure more, he would have had little for which to care; had he not expended ingenuity in preparing elaborate experiments with limited advantages, he would have had no occasion for greater expenditure; had he not expended his money and his vacations in procuring museum material and his energy in pestering acquaintances for generous donations of such material, he would have little labor in connection with a museum; had he not insisted upon the introduction of laboratory teaching no one else would have insisted upon it. But having a clear conception of duty, he has sacrificed himself deliberately. The great expansion of the scientific departments of American colleges is due to the exertions of the teachers of science; and they in many instances have received neither gratitude nor any other acknowledgment.

And yet not without reward, for the influence of the science teacher has gone out far beyond the college limits. The great discoveries, up to within a few years, were made by college professors, and these, applied by inventors, have changed the face of the civilized globe, while those to whom the world is indebted for its comforts are unknown even by name. Their work has spread intelligence and revolutionized educational methods. Children in the upper classes of grammar schools know more respecting the earth and the relations of nations than did the college graduate of forty years ago. The high school teaching of science is far in advance of ordinary college teaching as it was twenty-five years ago, and in some respects fully equal if not superior to that in a large proportion of American colleges to-day. One is guilty of no exaggeration in saying that high school graduates know as much of chemistry, physics, biology and geology, when they enter the freshman class, as is offered in many colleges, for in those schools the subjects are not taught

superficially. This fact cannot be stated too emphatically and it should be forced upon the attention of those in control of college affairs. With the broadening in science teaching there has come a similar broadening in other studies. Full of the self-sufficiency encouraged by the older system of education, the college graduate who has reached middle life does not recognize that the ordinary man and woman are intelligent, well-informed and, in some respects, as well drilled intellectually as he. The proof is at hand. The lightest of our monthly magazines finds a demand for articles upon mining, sociology, electrical inventions, applied chemistry, bridge building, of a type which would have been about as intelligible as Choctaw to the community forty years ago; newspapers publish detailed descriptions of apparatus for wireless telegraphy, discuss problems in psychology, the mechanics of flying machines and pay generously for elaborate articles upon earthquakes and volcanoes; even the children talk glibly about ohms, volts and ampères as they play with electric toys. The high school is, so to speak, 'abroad in the land'; its bell tolls the knell for colleges which persist in the old method of specializing to the last degree in subjects which concern chiefly the intellectual side of man—an intellect regarded by most defenders of that method as debased by sin—while compressing within narrow limits those studies which concern the direct work of the Creator himself.

This advance adds to the burden of the science teacher. The 'elements' of a science in college often covers, or should cover, an area almost as extensive as that of the whole science thirty-five years ago. It has become difficult for science teachers to be investigators. The hours devoted by others to relaxation are required by them for study; their summer vacations are employed largely in the effort to catch up with the progress in their branch or branches. It is remarkable that so much work and so much good work is done by them in the way of original research, largely, it is true, in hours which should be given to rest. But, in too many instances, the opportunity for thorough work is lacking even where there may be time. Instead of scores, there are now hundreds of investigators in every branch of research, many belonging to government organizations, many employed by great corporations that their discoveries may be utilized, and some connected with universities which do not overwork them; publications are scattered through hundreds of journals and the literature on any subject has become appalling, so that the task of consulting it is of itself almost enough to deter any but a man of means and leisure from undertaking systematic investigation. Libraries, museums and costly apparatus are essential now, where, half a century ago, little was required aside from will and mental ability.

Especial emphasis has been laid upon the burden of the scientific

side, because the writer is more familiar with its changes during the last thirty-five years; but the condition is serious enough for incumbents of many chairs not scientific. Men in most of the American colleges and universities are badly handicapped by routine work; not that too many hours are spent in actual teaching, but as a rule the teaching covers too many things, while too much is expected or required outside of purely college duties. The condition is unfortunate for the world, which no longer reaps the fruit of college men's work as investigators; but it is many times more unfortunate for the student. To be a thorough educator, the college instructor must possess the instinct and the experience of an investigator, otherwise he cannot train men to think. The present method of utilizing professors tends to convert them into superficial purveyors of second-hand knowledge; it must lead to decay in our educational system which has owed its virility to professors who were independent thinkers because they were thorough investigators.

The condition is serious, so serious as to inspire hope for the future. Many suggestions have been presented, most of them good but almost all of them premature. Changes more radical than any yet proposed must be made before those suggestions can be considered.

American colleges have still to contend with two fundamental difficulties—poverty and an ancient method of control.

A college professor can hardly administer the remedy for poverty, but he may suggest what is on the surface. There are too many colleges which ought to be merely academies, too many which should be high schools, too many so-called universities which ought to be modest colleges, and there are enough of true universities to supply the country's need for a long time. Unquestionably, coalition in some cases and consolidation in others would go far toward relieving the stress; but consideration of even this matter is premature, for a radical change in the method of control must be brought about before either coalition or consolidation can become possible.

Originally, in most of our institutions, the college was the only school under control of the degree-granting corporation and the professional schools which grew up around it had but a nominal connection, managing their own affairs, both educational and financial. But the college is no longer the all-important portion of our universities; professional, technical and scientific schools, some of them in part replacing the college, predominate and all are actually, as well as nominally, under one corporate control. The college itself is not the school of thirty-five years ago; the whole system of training has been changed, and there is offered not a narrow but a broad education. Yet one finds in control of the vast institution the same president as in the olden time, with powers like those of an academy principal and often with

the same sense of personal ownership; the same board of trustees, with authority and privileges as in the days when the college was the whole and itself little better than an academy. In other words, we are controlling the great university with its thousands of students in many schools, with its many groups offering hundreds of courses, after the fashion which prevailed when there was but one group of courses, arranged expressly with reference to the needs of those looking forward to the clerical profession. The method is not adapted to the conditions; as well try to manage the New York Central of to-day by the railroad methods of forty years ago.

The time has come for a complete reorganization of the system; the educational work and the business management must be under separate boards, and the boundaries of the provinces should be definite.

The faculties, each for itself, should control appointments of professors and instructors; should determine all matters concerning curricula; should decide questions as to expansion or contraction of work; should have the final word respecting internal arrangement of buildings—in short should be the supreme authority in all matters directly affecting the educational work. Matters affecting the work of the university as a whole should be referred to a council composed of representatives from all of the faculties whose determination should be final. In very many institutions most of these powers are still vested in the board of trustees, which means simply that in these matters the whole control is in the hands of one or two members; since no board of trustees can possibly be competent to decide respecting qualifications of candidates for professorships or upon changes in curricula, decisions respecting these matters are most likely to be rendered in deference to the opinion of some trustee or officer who is suppposed by the rest to know something about them. In other words, the individual trustees have transferred their powers while nominally retaining them.

The presiding officer of the council, the educational head of the university, should be one who has studied the educational problem from all sides; not necessarily a great scholar in any one department, but a broad scholar, possessing tact and executive force. Such men are not rare, though one may be pardoned for regretting that so many have chosen other professions in preference to that of college president. The faculties should select this officer.

The trustees should have charge of the financial interests of the institution. In some of our universities, those interests exceed those of some western states; even in less pretentious institutions they are very large. They are sufficient everywhere to require not merely close attention but an amount of business skill and shrewd foresight beyond that demanded by ordinary business of equal extent. The trustees cannot be the architects or the builders; but their work, if confined to its

proper province, would be so important that unless it were well performed, that of architects and builders would be imperfect. They should plan liberal things for the work, but should not leave the execution, as now, chiefly to one man. Under such conditions the bond between the boards would be close, for in frequent conferences each would become familiar with the general conditions and needs of the other, so that they would work, not merely in harmony, but also with the view to mutual helpfulness.

The writer has been informed that this plan is impracticable; that it has in itself the seeds of destruction; the faculties would be self-perpetuating bodies; conservatism would be crystallized; it is hard enough now to get rid of incompetent or antiquated professors, it would be impossible then; available funds would be applied to salaries and not to development; jealousies would paralyze the work; *et cetera* to the end of a list which does credit to its author's power of imagination.

An answer in part would be *Tu quoque,* for certainly trustees are usually self-perpetuating bodies and it is equally certain that crystallization of conservatism in trustee boards has not been the least of the difficulties with which energetic faculties have had to contend. It is quite possible that salaries might be increased, or that an effort would be made to increase them so that a college instructor could live in modest comfort upon his salary. But there is no need of trustee supervision to prevent selfish grasping of funds. Chairs have been divided, new courses established, new methods introduced, the grade of instruction elevated—all upon the initiative of the faculties, and this in face of the fact that such expansion means decreasing salaries.

With educational matters under control of the faculties more attention would be paid to the qualifications of candidates for appointments than to the qualifications of their supporters; there would be fewer instructors of the type which some regard as burdensome; a college professorship would not be a haven of rest in which a failure might be anchored by his friends; expansion at the expense of efficiency would cease; there would be an end to extreme specialization in narrow groups but a wiser specialization in studies of a different type. No doubt mistakes, and many of them, would be made, as college professors are like other men; but the faculties are less likely to err in their management than are those who know very little about educational affairs.

It has been suggested that strong men would not serve as trustees; but the suggested conditions would change the actual conditions very little so far as most of the trustees are concerned. It is altogether probable that able men would be much readier to serve than they are now. A man who would not entrust any part of his business to a college professor simply because he does not understand it, can hardly

hold college work in high esteem when he finds that, though almost wholly uninformed respecting it, he is thought competent to select the managers and to direct the method. It is not surprising that some of our modern trustees entertain little respect for college professors; the only wonder is that so many of them entertain any respect whatever. Under the proposed method, however, the trustee would be no longer a mere name, he would hold office with definite duties and definite responsibilities, whose nature he would understand. He could not fail to become familiar with some portion of the institution's work, for conference would bring every trustee into contact with representatives of the faculties. His personal interest in one department or another would be apt to take practical shape.

As business principles would prevail in the management, funds for endowments could be obtained with less difficulty because there would be less dread of waste through bad investment. Patrons would be more ready to found departments, equipped with men, materials and buildings, seeing in them more enduring monuments than mere memorials of stone.

The writer has been a college professor for thirty-three years. Familiar with the changes for good and ill to which this article refers, he has felt compelled to write without reserve and it may be with some emphasis, that the conditions may be brought sharply before those who really control the future of American colleges and universities. He appeals to that business common sense which characterizes the great majority of college trustees. American colleges and universities have outgrown their swaddling clothes; no amount of patching can make them fit; the new garments must be of different cut and of different material.

THE WORLD-VIEW OF A SCIENTIST: ERNST HAECKEL'S PHILOSOPHY.*

By Professor FRANK THILLY,
UNIVERSITY OF MISSOURI.

IN 1892 Ernst Haeckel, the celebrated biologist, delivered an address before a society of naturalists, in which he outlined his creed, his 'Glaubensbekenntniss eines Naturforschers.' This address was printed under the title 'Monism as a Bond between Religion and Science,' and is now in its tenth edition. In 1899 a more elaborate account of Haeckel's philosophy was given to the world in a book called 'The World Riddles.' Within a few weeks after the appearance of this work 10,000 copies has been sold. It was at once translated into English and figured prominently in the lists of the most popular books of the day in our country. The magazines and even daily papers have published review after review of the 'World Riddles'; pamphlets and books have been written about it, and the interest still continues.† The Academy of Turin, Italy, has declared the 'World Riddles,' to be the best book written during the last four years of the nineteenth century, and has awarded to its author the Bressa prize of 10,000 lire. The work has raised the feelings of many usually tranquil persons to a higher pitch of excitement, provoking extravagant expressions of admiration from some, and words of passionate indignation from others. There is joy in the camp of the Haeckelites, where the author is glorified as the greatest philosopher of the age, while in the ranks of the opponents there is angry contempt for a man who, so it is said, is an absolute ignoramus in matters of philosophy and in everything outside of his own *Fach*, and some critics are even willing to call in question his standing as a biologist. The turmoil is increasing, the angry voices are growing louder, and we hear words of reproach and insult on both sides, which we are not accustomed to hear from the lips of men of science. Some of the attacks which have been made upon Haeckel have passed the bounds of the respectable. One fire-eater, a Christian theologian, has taken the matter so to heart as to make an entirely personal affair of it. 'My remarks,' he says, 'are an attack upon Haeckel's honor, and are intended as such.'‡ The conflicts between the realists and

* Lecture delivered at Cornell University under the auspices of the Sage School Philosophical Club.

† Schmidt, 'Der Kampf um die Weltraethsel,' mentions 72 German titles, to which may be added at least two more, making with his own work 75.

‡ Loofs, 'Anti-Haeckel.'

nominalists during the middle ages could not have been more bitter than this Haeckel controversy threatens to become, and we need have no fear, so far as I can see, that the occupation with intellectual things is blunting the emotional side of the modern thinker's soul.

It is not my intention to join in the hue and cry against this man who has dared to offer the world a *Weltanschauung,* nor am I willing to stamp his work as unworthy of notice. It is true, Haeckel has provoked a fair share of the abuse that has been heaped upon him by his own intolerant attitude, but after all two wrongs do not make a right. I believe that it will be worth our while to hear patiently what Haeckel has to say, and then to subject his philosophy to the tests by which it will be judged at last when the discordant voices of the present are hushed and the author and his critics are sleeping in their quiet graves. A work that has made such an impression upon an age as the 'World Riddles' can not be ignored or thrown out of court without a hearing, and the hearing must be impartial and temperate, such a hearing as it is bound to receive at the bar of history. It expresses the views of large numbers of natural scientists to-day, although few would dare to make public confession of their faith, as the fearless Jena biologist has done; and as an expression of opinion coming from such a quarter, it deserves attention. I shall therefore try in what follows to give an exposition of Haeckel's thought, and to examine its value as a theory of the universe.

And first let us turn to our philosopher's theory of knowledge.* Our true knowledge, he says, is real in its nature; it consists of ideas (*Vorstellungen*) which correspond to really existing things. It is true we cannot know the innermost essence of this real world, of the thing in itself,† but we are convinced by impartial and critical observation and comparison that the external world makes the same impressions upon the sense-organs and brain of all normal rational individuals, and that the same ideas are formed by all persons whose organs of thought function normally. All our knowledge depends upon two physiological functions—upon sensation and upon the combination of the impressions thus gained, by association. The experiences which we receive from the external world through our sense-organs and sense-centers in the brain are transformed into ideas by other brain-centers, and these are combined into inferences by association. These inferences are both inductive and deductive, processes which have equal value. Other complicated brain operations, the formation of chains of reasoning, abstraction and conception, imagination, consciousness, thought and philosophy, are all functions of the ganglionic cells of the cerebral cortex.‡

* See particularly 'Die Weltraethsel,' pp. 337ff.

† See also pp. 437f, *op. cit.*, and 'Monismus,' p. 40.

‡ See also 'Weltraethsel,' pp. 19f.

But our sense-activity is limited; we can discover only a part of the qualities possessed by the objects of the external world. The civilized man transforms his sense-impressions into specific sensations in the sense-centers of the cortex, and combines these by association in the thought-centers into ideas or presentations, and by further combination of the idea-groups he finally reaches connected knowledge. But this knowledge always remains unsatisfactory, unless the fancy supplements the insufficient combining power of the understanding and by association of memory-images combines remote cognitions into a connected whole. In this way new ideas arise which alone explain the perceived facts and satisfy the causal need of the reason.

The ideas which fill the gaps in our knowledge, or take its place, we may call belief (*Glaube*). We are forced to belief in science. We surmise or assume that a certain relation exists between two phenomena although we do not know it with certainty. In the case of knowledge of causes we form a hypothesis. But only such hypotheses can be admitted in science which do not contradict known facts, *e. g.*, in physics, the doctrine of ether-vibrations; in chemistry, the assumption of atoms and their affinity; in biology, the doctrine of the molecular structure of the living plasma.

The explanation of a larger series of connected phenomena by the assumption of a common cause we call a theory. Here, too, faith or belief in the scientific sense is indispensable, here, too, the poetic fancy fills the gap which the understanding leaves in the knowledge of things. A theory can therefore be regarded only as an approximation to truth; it can always be supplanted by a better theory. But theory is indispensable in science, for theory alone explains the facts by assuming causes. Hence whoever wishes to do entirely without theory and to construct pure science upon nothing but 'certain facts' relinquishes all knowledge of causes and the satisfaction of the causal need of the reason.* Examples of such theories are the theory of gravitation, the cosmological nebular theory, the principle of energy, the atomic theory, the vibration theory, the cell theory, the theory of descent. They explain a system of natural phenomena by assuming a common cause for all the particular facts of their territory. This cause itself may be unknown in its essence or be a merely provisional hypothesis. Gravitation, energy itself, ether, the atom, heredity, may be regarded by sceptical philosophers as 'mere hypotheses,' as products of scientific belief, but they are indispensable until they are replaced by a better hypothesis.

This theory of knowledge is almost identical with that offered by Epicurus three centuries before Christ. With respect to the problem

* See also 'Monismus,' p. 37.

of the origin of knowledge it is an extremely naïve form of empiricism and associationism. It is the old naïve story about sensations putting themselves together and forming ideas, of ideas putting themselves together and forming thought, personality, and all the other higher processes of consciousness.* It is true Haeckel does incidentally speak of innate knowledge *à priori* in connection with innate instincts, which he explains as having originally been acquired empirically through race-experience,† but, so far as I see, this view does not affect his theory. Haeckel's empiricism is as unsatisfactory as it is simple, and has about as much value as the old theory of creation has in Haeckel's own science. Kant and modern epistemology seem to have made no impression whatever upon the great German biologist.

With respect to the problem of the nature of knowledge Haeckel's position is somewhat vacillating. He tells us that we do not know the inner essence of things in themselves; indeed, he afterwards hints that perhaps there are no such things in themselves for all we know. At the same time space and time are realities, objective realities, real entities: the existence of space and time is now definitely proved.‡ Here we seem to get a jumble of nearly all possible standpoints, of realism, semi-realism and idealism—one after another. That is (1) there is a thing in itself; we do not know its essence, however, but only its effects upon us; (2) for all we know there may be no thing in itself, we do not know and we do not care, we can get along without it; (3) space and time are realities, that is, either things in themselves or the attributes of things in themselves.

The same uncertainty prevails with respect to another point. Haeckel is a dogmatist and sceptic by turns, as the occasion suits him. We cannot know everything with certainty, we cannot get along without faith in science. The theories of science are articles of faith, provisional assumptions which may be overthrown at any time. Among such hypotheses Haeckel enumerates nearly all the great theories of the different sciences and also his own philosophical system§ But this humility is merely a passing stage with our philosopher; his attitude is generally dogmatic; the tone of his book is that of a man who is absolutely sure of his result. Thus after having told us that certainty is impossible in science, that we must fill the gaps in our knowledge by faith, he declares dogmatically that the existence of ether, cosmo-ether, as real matter, is to-day a positive fact and not a mere hypothesis."‖ We can prove its existence by electrical and optical experiments;

* See 'Weltraethsel,' p. 141.
† P. 144.
‡ P. 283.
§ See Preface to 'Weltraethsel.'
‖ Pp. 260f.

indeed, we can *see* the vibrating ether.* It is likewise a certain historical fact that man is descended from apes, etc.† The discovery of the fossil ape-man of Java proves conclusively the descent of man from the ape.‡ The existence of space and time is also definitely proved. The historical evolution of the human soul from a long series of higher and lower mammalian souls must be regarded as a scientifically proved fact.

We are now ready to take up Haeckel's metaphysics. We shall first discuss the principles upon which his entire system rests and then consider their application to inorganic nature, organic nature and the psychical world.

In the celebrated address which Du Bois-Reymond delivered in the year 1880, and which was afterwards published as the 'Seven World Riddles,' he proposed seven problems: (1) The essence of matter and energy; (2) the origin of motion; (3) the origin of life; (4) the apparently purposive arrangement of nature; (5) the origin of sensation and consciousness; (6) rational thought and the origin of language; (7) the question of free will. Questions 1, 2 and 5 he regards as impossible of solution or transcendent; 3, 4 and 6 are difficult, but can be solved. On question 7 he is undecided. Haeckel makes short work of these riddles. The problem of matter and energy, the problem of motion and the problem of consciousness are solved, he thinks, by his conception of substance; the problem of life, the teleological problem and the problem of reason by the modern theory of evolution, while the free will problem is no problem at all, but a dogma based on mere illusion.

The conception of substance is therefore Haeckel's fundamental principle. Let us see what it means. There is one underlying prin- are two different aspects.§ This substance is infinite, indestructible and eternal; it fills the infinite space and is in eternal motion. The matter and energy therefore in the universe are constant. This gives us the laws of the conservation of matter and of energy, which really form one single law, the law of substance, the cosmological ground law, the law of the constancy of the universe, which follows necessarily from the principle of causality. This universal substance reveals to us two different aspects, two fundamental attributes: matter, the infinite extended substance-stuff, and mind (*Geist*), the all-embracing substance-energy. It is God and nature at the same time; body and mind

* 'Monismus,' p. 16.
† 'Weltraethsel,' p. 97.
‡ P. 100. See also pp. 18, 73.
§ See 'Weltraethsel,' pp. 243ff.
‖ P. 15.

(or matter and energy) are inseparably connected.* God is not an external being, acting from without, but a divine power or moving spirit, the cosmos itself; the phenomena of surrounding nature, organic as well as inorganic, are merely different products of one and the same original force, different combinations of one and the same original matter.† All the individual objects in the world, all the individual forms of existence, are merely transitory forms of the substance, accidents or modes. These modes are corporeal things, material bodies, when we consider them under the attribute of extension (as filling space); forces or ideas, when we regard them under the attribute of thought (or 'energy'). Matter (the stuff filling space) and energy (the moving force) are two attributes of one substance.‡

This view Haeckel calls monism, and tries to distinguish from materialism as follows: (1) Our pure monism is neither identical with theoretical materialism, which denies mind and resolves the world into a sum of dead atoms, nor with theoretical spiritualism (recently termed *Energetik* by Ostwald), which denies matter and regards the world as a spatially arranged group of energies or immaterial natural forces. (2) Matter can never exist and act without mind, nor mind without matter. 'We adhere to the pure and unambiguous monism of Spinoza,' says Haeckel; 'matter, as the infinitely extended substance, and mind (or energy) as the sentient (*empfindend*) or thinking substance, are the two fundamental attributes or ground properties of the all-embracing divine world-being, the universal substance.'§

If we interpret Haeckel's system in the light of the preceding statements, we certainly reach a kind of monism. Mind and matter are both aspects of an underlying substance. There is no difficulty in understanding what Haeckel means by the material aspect of the substance: it is the space-filling, extended stuff. It is not so easy to see, however, what the other phase of substance, the mental aspect, is. This attribute the philosopher calls mind or *Geist,* thought, the sentient side, energy, the moving force. In the chapter on substance we are left under the impression that these attributes are not independent entities, but attributes of something behind them, of a thing in itself called the substance. This impression is strengthened by Haeckel's concluding reflections at the end of his book:

We confess at the outset that we know just as little of the innermost essence of nature to-day, as did Anaximander and Empedocles 2,400 years ago,

* P. 23.

† 'Monismus,' p. 13.

‡ 'Weltraethsel,' pp. 249f.

§ 'Weltraethsel,' p. 23. 'Monismus,' p. 27: "For our monism an 'immaterial living spirit' is as unthinkable as a 'dead spiritless matter'; in every atom both are inseparably combined. The other systems conceive force and matter as two essentially different substances."

Spinoza and Newton 200 years ago, or Kant and Goethe 100 years ago. Yes, we must even confess that the real essence of the substance becomes more wonderful and mysterious the more deeply we penetrate into the knowledge of its attributes, matter and energy, the more thoroughly we become acquainted with its numberless manifestations and their evolution. What is behind the knowable phenomena as a 'thing in itself' we do not know even to this day. But remaining true to his general tendency to be inconsistent with himself our author goes on to say: But what do we care about this mystical 'thing in itself' anyhow, when we have no means of investigating it, when we do not even know clearly whether it exists or not. Let us therefore leave it to the 'pure metaphysicians' to ponder fruitlessly over this ideal ghost, and let us rejoice instead as 'true physicists' in the enormous advances which our monistic philosophy of nature has actually made.*

We see, Haeckel's conception of substance changes like a chameleon before our very eyes. We are first told that there is a thing in itself, then that we do not know what it is, and finally that we do not even know that it is. We are naïvely told that the notion of substance will solve all riddles, make all things clear to us, then we are informed that it is a mystery, the greatest mystery of all, and finally it vanishes into thin air before our very gaze, and turns into a phantom which perhaps does not even exist. After making the conception of substance do service as a principle of explanation for 436 pages of his book, after having employed it as the support of real attributes, space, time and energy, Haeckel suddenly dismisses it as an utterly useless piece of metaphysical furniture.

But these are not the only inconsistencies in the doctrine of substance. We are told that substance is unknowable, that matter and force are its attributes. We are told that God, the thing in itself, is an intramundane being and acts in the substance as force or energy.† That is, the thing in itself is force. Yes, perhaps the original hypothetical chemical element, the prothyl, is the substance; ‡ perhaps the world-ether is the creating god-head.§ What does all this mean? The substance perhaps does not exist; the substance does exist, but is unknowable; the substance has real attributes, and we know them; the substance is energy; the substance is perhaps prothyl; the substance is perhaps the world-ether. Haeckel is certainly right in his remark that consistent thinking is a difficult business.

There is another point worth noting at this place which will come up again. Haeckel speaks of the mental aspect of the substance as mind, thought, sensation (*Empfindung*), energy, moving force. This is something like Schopenhauer's will, only that it is not a substance, but the attribute of a substance. As an attribute distinct from the

* 'Weltraethsel,' pp. 437ff.

† 'Weltraethsel,' p. 333.

‡ 'Weltraethsel,' p. 426.

§ 'Monismus,' pp. 16, 37.

other attribute, matter, it must be immaterial, something of the same nature as consciousness, only not conscious on the lower stages of existence. It seems to account for all movement and thought in the world.

Now that we have become acquainted with Haeckel's fundamental principles, let us observe what application is made of them. We shall take up in order the inorganic world, organic nature and psychic life.

The substance fills infinite space as a continuum. It is endowed with a mechanical form of activity, with a striving (*Streben*) to become dense or to contract. In this way little centers are formed of the parts of the universal substance which Haeckel calls pyknatoms, and which possess sensation (*Empfindung*) and impulse or striving (*Streben*), will-movements of the simplest kind, and hence are in a certain sense animated.* The atoms are not dead mass particles, but living elemental particles, endowed with the power of attraction and repulsion; love and hate are merely different expressions for this power of attraction and repulsion.† These original atoms are probably of the same size and essence, but they are not divisible. Their form is most likely spherical; they are inert (in the sense of physics), unchangeable, inelastic, not penetrable by ether. They have another quality, chemical affinity, an inclination to combine and to form little groups in a uniform way. These fixed groups of original atoms are the so-called elemental atoms, the known indecomposable atoms of chemistry. Hence the qualitative differences of our chemical elements are conditioned solely by the different number and configuration of the homogeneous original atoms. We do not know what is the nature of these original atoms themselves; perhaps it is prothyl.‡

These atoms do not float in empty space, but in a continuous extremely thin intervening substance which represents the non-contracted part of the original substance. In this way the substance, which in its original state of rest has the same density throughout, differentiates into two parts: the pyknatoms, ponderable matter, and the intervening ether, the imponderable matter. The result of this separation or differentiation is a constant struggle between these antagonistic parts of substance, and to this struggle all physical processes are due. As was said before, these atoms are not dead and movable by external forces only; they possess sensation and will (in the lowest degrees, of course), they experience pleasure in the process of contraction (*Verdichtung*), pain in the process of tension (*Spannung*); they strive after the first and struggle against the last. Hence atoms are endowed with a universal 'soul' of the most primitive kind. The

* 'Weltraethsel,' pp. 250ff.

† 'Monismus,' p. 14.

‡ 'Monismus,' p. 17.

same is true of molecules or mass-particles, which consist of two or more atoms.* But these elementary psychical activities which are attributed to the atoms are unconscious processes. Consciousness and soul-life are not identical terms; consciousness forms but a part of soul-phenomena; the largest part of the latter is unconscious.† There is no immaterial substance; experience never reveals such a thing, no force that is not bound to matter, no form of energy that is not mediated by movements of matter.

There is no difference between organic and inorganic nature. All phenomena are explained by physico-chemical forces in each realm. The doctrine of the vitalists is absurd. The peculiar chemical-physical properties of carbon—particularly of the carbon compounds—are the mechanical causes of the peculiar movements which distinguish the organic from the inorganic world. Life, in other words, is the product of inorganic nature, the living plasm originated from inorganic carbon compounds.‡ The universe is a unity, all natural forces are one. All the phenomena of organic life are subject to the universal law of substance, as much so as inorganic phenomena.

The higher forms of life are developed from the lower in accordance with the principles of the theory of evolution as advanced by Darwin. That man is descended from the higher apes is now an absolutely proved fact. The idea of purpose, the teleological explanation, which was eliminated from physical science long ago, can not be accepted in biology. The theory of natural selection proposed by Darwin explains the origin of so-called purposive organisms by purely mechanical causes. There is no purposive impulse discoverable anywhere in organic life; everything is the necessary result of the struggle for existence, which acts as a blind regulator and not as a foreseeing God, and which causes the transformation of organic forms by the reciprocal action of the laws of heredity and adaptation. Nor is there any such purposiveness in our moral life or in history, individual or racial. Mechanical causality explains everything.

We turn now to Haeckel's philosophy of soul, to which he devotes one third of the entire space of the 'Weltraethsel.'§ The soul is a natural phenomenon; hence psychology is a branch of natural science, particularly of physiology. The so-called psychologists are ignorant of anatomy and physiology, hence the largest part of psychological literature is to-day worthless waste paper. The prevalent conception of soul life regards soul and body as two different beings, says Haeckel, and this view has nothing to stand on. Soul life is a sum total of vital

* 'Weltraethsel,' p. 259. See also 'Monismus,' p. 14.

† 'Weltraethsel,' pp. 206f.

‡ 'Weltraethsel,' pp. 296ff.

§ Pp. 101–243.

phenomena which are like all others bound to a definite material substratum called the psychoplasm.* In this sense our view is materialistic. The processes in the lower forms of soul life, excitability, reflex movement, sensibility (*Empfindlichkeit*) and the impulse of self-preservation are directly conditioned by physiological processes in the plasm of their cells, by physical and chemical changes, which may be explained partly by heredity, partly by adaptation. The same may be said of the higher forms of soul life, for they have developed from the lower forms.

A study of comparative psychology and folk psychology, of ontogenetic and phylogenetic psychology, will show that organic life, in all its gradations, develops from the same forces of nature, from the physiological functions of sensation and movement. The plasm is the indispensable bearer of the psyche. The psyche, or soul, is not a separate being; the term psyche or soul is a collective term for the sum-total of the psychic functions of the plasm. In this sense the soul is a physiological abstraction, like the concept metabolism or generation. The 'soul' can not function without a certain chemical and physical composition of the psychoplasm.

All living organisms are sensitive (*empfindlich*); they distinguish the states of the surrounding world and react upon the same by certain changes within themselves. Light, heat, mechanical and chemical processes in the environment, act as stimuli upon the sensitive psychoplasm and cause changes in its molecular composition. There is an ascending scale of soul life, from the simplest forms of organic life where the entire protoplasm is sensitive and reacts, down to the most developed form, where we have a centralized nervous system and conscious sensation, the highest psychic function. We have cellular ideas, histonal ideas, unconscious ideas of the ganglionic cells, conscious ideas in brain cells, all of them being physiological functions of their psychoplasm. Only on the highest stages of animal organism does consciousness develop as a special function of a particular central organ of the nervous system. When the ideas become conscious, and when certain brain centers become highly developed, making possible an extensive association of conscious ideas, the organism becomes fitted to perform the highest functions which we characterize as thinking and deliberation, understanding and reason. We have the same stages in the development of memory and the association of ideas. There are many psychic products of this association of ideas, among them the unity of consciousness. Reason, the instincts, the emotions and the will are explained similarly. All these phases of psychic life are at first unconscious, all are functions of more or less complicated forms of organic matter, and all are subject to physical laws. The great riddle

* See also 'Monismus,' p. 21.

of the origin and nature of the soul is solved by phylogenetic psychology. The human soul is evolved from a long series of other mammalian souls. The historical evolution of the human soul out of a long series of higher and lower mammalian souls must be regarded as a scientifically proved fact.

Consciousness is a natural phenomenon like all the other soul activities. Consciousness is inner intuition, perception, *Anschauung,* an inner reflection or mirroring. We may divide it into world-consciousness and self-consciousness. The former embraces all possible phenomena of the external world which are possible to our knowledge; the latter is an inner mirroring of our own soul activity, of all ideas, sensations, strivings, and will acts.* Consciousness and psychical life are not identical; psychical life extends farther than consciousness. Unconscious sensations, ideas and impulses also belong to soul life; indeed, this field is larger than the other.

Consciousness is bound to a centralized nervous system. The presence of a nervous central organ, highly developed sense-organs and association-groups, is essential to the existence of unitary consciousness. Protists have no developed ego-consciousness; their sensations and movements are unconscious. In short there is no consciousness until we reach the higher animals. The elementary psychic activities are all unconscious. The riddle of consciousness is no riddle at all. The neurological problem of consciousness is only a special case of the all-embracing cosmological problem, of the problem of substance. The problem of consciousness is a physiological problem, and as such to be reduced to the phenomena of physics and chemistry. Consciousness is therefore only a part of the higher soul activity, and as such dependent upon the normal structure of the corresponding soul organ, the brain. It is absolutely dependent upon the chemical changes of the brain substance. It is not an immaterial being, but a physiological function of the brain. The new-born child is without consciousness; consciousness is a late development, arising first when the child learns to talk.

It is only in the significant moment when the child says I for the first time, when its ego feeling becomes clear, that its self-consciousness begins to sprout, and with this the opposition to the external world.

With the death of man all physiological activities cease, and with them the 'soul,' that is, that sum of brain functions which psychical dualism regards as a separate being, independent of the other manifestations of the living body. The protozoa are just as mortal in the physiological, and hence also in the psychological, sense as the metazoa. Energy and matter are inseparably connected. We distinguish between the psychical energy (sensation, presentation, willing) and psychical

* 'Weltraethsel,' pp. 197ff. See also 'Monismus,' pp. 22f.

matter, by which alone the same can act, that is, the living plasma. The soul is actual; it is the sum of the physiological functions of the material organs. The human soul is a collective term for a sum of brain functions, and these are like all other life processes conditioned by physical and chemical processes, and hence like all the rest subject to the law of substance.

Let us now see what has become of Haeckel's original monistic theory. According to the original proposition there is one underlying substance of which matter and energy are the attributes. What this substance is, no one knows; perhaps it does not exist at all; perhaps it is force; perhaps prothyl, perhaps ether. But never mind that. We have the two aspects of it in extended space-filling stuff, and the sentient energy. All of a sudden this unitary substance begins to turn itself into a plurality of atoms or pyknatoms; the one becomes the many, monism becomes pluralism. How is this to be explained? It is all very simple to Haeckel. Atoms have souls, feelings and desires, and these properties cause the atoms to contract.

> Without the assumption of an atom-soul, says Haeckel in another place,* the most common and most general phenomena of chemistry are inexplicable. Pleasure and pain, desire and aversion, attraction and repulsion must belong to all mass-atoms; for the movements of the atoms which must take place in the formation and separation of every chemical combination can be explained only if we ascribe to them sensation and will (*Empfindung und Wille*).

That is, the physical pluralism is explained by assuming a pluralism of forces. But why the unitary substance should desire to differentiate we are not told. But ignoring this difficulty, we note that these atom-souls or soul-atoms, these properties of sensation and will, cause the atoms to contract, and hence cause motion. That is, the attribute of energy, sentient force, mind, thought, or whatever else Haeckel may choose to call it, causes motion, makes matter move, produces a change in the other attribute. Almost in the same breath we are told that there is no form of energy which is not caused by movements of matter.† That is, the energy causes the movement, and the motion causes the energy. These statements not only contradict each other, but are out of harmony with the original standpoint of Haeckel, according to which mind and matter are attributes of an underlying substance, dependent upon this and not upon each other.

Haeckel's pure monism, we see, seems to turn into the much-despised dualism. But this is only a passing stage in the philosophical drama. We are hurried on rapidly to the denouement in the chapters on the soul, where the so-called psychical processes become the functions of physiological processes, of physical and chemical changes. We

* 'Perigenesis der Plastidule,' pp. 38f.

† 'Weltraethsel,' pp. 255f.

have already become acquainted with Haeckel's philosophy of mind; let us here simply accentuate the phases of it which do not agree with the fundamental principles. Soul life is the sum-total of vital phenomena which are all bound to a material substrate, conditioned by physiological functions. Soul is a collective term for the sum-total of the psychic functions of the plasm. 'Soul' is a collective term for a sum of brain functions, which are, like all life-activities, conditioned by physical and chemical processes. Soul life is unconscious until we reach the higher animals where it becomes conscious. Consciousness, however, is merely a development from the lower forms of psychic life and, like these, a function of physiological processes. It is dependent on the chemical changes of the brain; it is a physiological problem and as such solved by physics and chemistry. The sentient energy with which we began, which was at least equal in dignity with matter at the outset, and which assumed importance enough in the scheme to cause the matter to move, to attract and to repel, is now made the function of matter. Matter is the substrate, the substance; soul or mind the function of matter, housed in the latter and dependent upon it. Matter has become king; energy or mind its slave. Our so-called pure monism has changed into materialism, if not in the sense that it reduces everything, energy included, to matter and motion, at least in the sense that it makes this energy an attribute, a function of matter.

Besides the inconsistencies which we have noticed all along the line, there are difficulties in the system upon some of which we have already lightly touched. The continuous substance filling infinite space and endowed with infinite energy must do something if a cosmos is to be formed. It begins to differentiate and to form atoms. We are told why it does so: it has the unconscious impulse to do so, it is endowed with the properties of love and hate, which are only different names for attraction and repulsion. Why the infinite substance should want to do all this, we are left to figure out for ourselves. It is worth noting here, however, that Haeckel introduces the conception of purposive impulse into his explanation of the cosmos, an unconscious impulse or striving, it is true, but still a force attempting to account for the movements of the atoms. He does not therefore repudiate the teleological explanation *in toto,* as he claims to do, but only conscious teleology.

But in spite of all this the theory does not explain how these animated atoms floating in the ether can produce a world. We have here the same old difficulty which was presented to us by the first Greek atomists. In fact it is somewhat increased. Each pyknatom acts spontaneously; it is not a dead thing buffeted into place by other dead things, but a living thing that seeks its place, that strives to be united with other atoms which also strive, and their harmonious strivings give us a world. This is certainly a mystery of mysteries. Why the little atoms

should band themselves together and form molecules, why the molecules should fall into line and form larger bodies of matter, is not explained.

The same difficulty meets us, of course, in the philosophy of organic life. Haeckel supplies us with any number of animated pyknatoms, but we are at a loss what to do with them. How are they to form organisms? Of course, it is just as easy for them to form a simple piece of protoplasm as it is for them to form a planetary system, but there is poor consolation in that when it is a mystery how they can do either. Moreover the mysteries multiply a thousandfold when we pass from the very simplest form to the higher organisms. It is perhaps easy enough to describe what happens, to watch the process of cell division under the microscope, to trace the development through a series of stages, but why should the atoms group themselves in such a way as tc form now a polyp, now a man. Each cell has its soul, it is true, unconscious impulse; and combinations of cells have corporate souls in turn, but they sit there helpless, unable to do anything; indeed what can they do, being merely a sum of vital phenomena, a collective term for the sum-total of physiological functions of the psychoplasm? The theory of evolution can not help us here, and the great Darwin frankly confessed that much. It can help us to see that if a certain form is given, that form will tend to survive if it is adapted to its surroundings, but why it should be in the first place, and why it should develop new and more appropriate characteristics in the course of time, it cannot tell us. As has been said by Schurman,* the theory of evolution may explain the survival of the fittest, but it can not explain the arrival of the fittest.

It is strange that Haeckel should have found it necessary to endow his atoms with souls, and then have such a dread of attributing a principle of unity to organic forms. If the atom can have a soul or energy that makes it seek out some atoms and avoid others, why not endow the organism with a soul or force that will do something? I do not mean to advocate the renewal of the doctrine of vitalism in biology, after the fashion of Reinke† and other modern biologists, but I do not see why a man who gives atoms and cells and groups of cells souls, and who uses the atom-souls as a principle of explanation, should draw the line at organic forces or souls. If vitalism and teleology are acceptable in the inorganic world, why should they be so utterly out of the question in the organic realm?

The philosophy of mind is also full of difficulties. The existence of psychical life is not explained, but assumed. The substance is endowed from the beginning with sentient energy, energy that feels pleasure and

* 'The Ethical Import of Darwinism.'

† 'Die Welt als That.'

pain, loves and hates, has desires and aversions, but these states are all unconscious. Unconscious sensations, pleasures, pains and impulses are greater riddles than the things they are manufactured to explain. Haeckel seems to feel this when it comes to organic life, for here he identifies these unconscious processes with physical and chemical forces, though he is vacillating on his point as usual; the physical processes are sometimes the forces themselves, sometimes the functions of these forces. Out of these unconscious processes consciousness arises in the brains of higher animals. The thing is as simple as it can be. Ideas which have been unconscious mirror themselves in the brain, begin to look at themselves. Consciousness develops as a subjective mirroring of the objective processes in the neuroplasm of the soul cells* and the thing is done. What could be fairer than that? And then these mirrored ideas, these ideas or rather brain processes that have suddenly taken it into their heads to look at themselves, add themselves together and form personalities and all higher processes of mind. The whole problem of existence is a problem of arithmetic. Atoms add themselves together to form bodies, bodies add themselves together to form worlds, ideas add themselves together to form thought, science, philosophy. Instead of answers to problems we get new and more difficult problems. It is no explanation of soul life to assume it as an attribute of the substance; it is no explanation of consciousness to deduce it from unconscious processes; it is no explanation of the human mind to conceive it as a sum-total of ideas.

This gives us Haeckel's philosophy of nature, his philosophy of life and his philosophy of mind. He believes that he has solved for us the problem of the essence of matter and energy, the origin of motion, the origin of life, the purposive arrangement of nature, the origin of thought and language, the origin of simple sensation and consciousness. The problem of matter and energy is solved by making matter and energy attributes of an underlying substance which is a greater riddle than they, and which perhaps does not even exist. We are never told what the essence of any of these things is. Afterwards matter seems to become the substance and energy its function. Energy is conceived as sentient force, as unconscious psychical life, and all the processes of soul life and consciousness are regarded as different forms of it or as functions of it. Matter, in other words, is the bearer of the different forces of nature, from the forces of attraction and repulsion or unconscious love and hate up to consciousness. Matter is king, energy is the subject. The origin of motion is not explained either. We are told that the substance is in eternal motion: 'motion is as immanent and original a property of the substance as sensation.'† We are also

* 'Weltraethsel,' p. 151.

† On page 253 the substance seems to be conceived as originally in a state of rest.

told that force or sentient energy is the cause of motion. If we say motion is original and eternal, we do not explain it, but assume it. If we say it is the effect of force or energy, then we are explaining it by creating a new problem. The origin of life is explained in a general way as the product of inorganic nature; the living plasm originates from inorganic carbon compounds. The physico-chemical properties of carbon are the mechanical causes of the movements of organic bodies. But what are these physical and chemical properties? If they are themselves movements, then we have simply pushed the problem back a station; if they are forces or the so-called sentient energy, then we have avoided vitalism in the organic world by previously introducing it into the inorganic world. As for the problem of the purposeful arrangement of nature, we must agree with Haeckel that the theory of evolution throws a great deal of light upon it, but we can not agree with him that it removes all difficulties and solves all riddles, as we have already pointed out.

In conclusion let us take up Haeckel's ethics and religion. The practical laws, he declares, must be in harmony with a rational *Weltanschauung*. Our ethical system must therefore be in harmony with the unified conception of the cosmos. The universe forms a single complete whole, the mental and moral life of man forms a part of this cosmos, hence our natural order is a unitary one. We have not two separate worlds, a physical-material world and a moral-immaterial world, but one.

The monistic cosmology has shown that there is no personal God; comparative and genetic psychology has shown that there is no immortal soul; monistic physiology has shown that there is no freedom of the will. The doctrine of evoluton shows that the eternal, necessary laws of nature which govern the inorganic world are valid also for the organic and moral world. This destroys the Kantian dualism in ethics. But there is also a positive side to ethical monism. It shows that the feeling of duty does not rest upon an illusory categorical imperative, but upon the real ground of the social instincts which we find in all higher gregarious animals. It regards as the highest aim of ethics the establishment of a healthy harmony between egoism and altruism. Man has duties towards himself and duties towards others. Both impulses, egoism and altruism, are natural laws which are equally essential to the existence of family and society. Egoism makes possible the self-preservation of the individual, altruism that of the species. The social duties are only higher developments of the social instincts. In civilized man all ethics, theoretical and practical, is connected as a normative science with his philosophy and religion. The golden rule is the fundamental law: Love your neighbor as yourself. Several christian rules of morality contradict this rule: (1) Contempt of self; exaggeration of

love of neighbor at expense of self; (2) contempt of body; (3) contempt of nature; (4) contempt of civilization; (5) contempt of family-life; (6) contempt of women.

As to religion Haeckel has this to say. Many scientists regard religion as a thing of the past. They think that the clear insight into the evolution of the world which we have obtained completely satisfies not only the causal need of our reason, but all the highest emotional needs of our nature. This view is in a certain sense true. For a perfectly clear and consistent conception of monism, the notions of religion and science become identical. Only a few decided thinkers reach, however, this view, fewer still have the courage or feel the need of expressing it.

Modern science must not only destroy the illusions of superstition, but erect a new edifice for the human emotions: a place of reason in which we may reverently adore the true trinity of the nineteenth century, the trinity of the true, the beautiful, and the good.

Just as the ancient Greeks embodied their ideals of virtue in the forms of gods, we can give our ideals of reason the forms of goddesses. The Goddess of Truth dwells in the temple of nature, in the green forests, upon the blue seas, on the snow-covered mountain-peaks. The ways of approach to this goddess are loving investigation of nature and its laws, the observation of the infinite world of stars by means of the telescope, and of the infinitely small world of cells by means of the microscope, but not senseless prayers and ceremonies.

Our ideal of virtue largely coincides with the christian ideal, as expressed in the Gospels and Paul's Epistles. The best part of christian morality consists in the rules of humanity, of love and forbearance, of compassion and beneficence. We place as much value, however, upon egoism as upon altruism; perfect virtue consists of a harmony between these.

The extension of our knowledge of nature, the discovery of countless beautiful forms of life, has awakened a new sense of the beautiful in us. Every blade of grass, every bug and butterfly, reveal beauties which we usually pass by. The admiration with which we regard the starry heavens and the microscopic life in a drop of water, the awe with which we examine the wonderful action of energy in the moved matter, the reverence which we feel in the presence of the law of substance,—all these are parts of our emotional life which come under the notion of natural religion.

Our monism also teaches us that we are children of the earth and therefore mortal, that we can enjoy the glories of this planet for a little while.

The modern man who possesses science and art—and hence also religion—needs no special church, no narrow enclosed space in which to worship. For everywhere in open nature, where he turns his eyes upon

the infinite universe or upon a part of it, everywhere he finds besides the hard struggle for existence the true, the beautiful and the good everywhere he finds his church in glorious nature herself. Still, it will correspond with the particular needs of many persons to have beautiful temples and churches to which to retire, and these they should have.

We have examined Haeckel's philosophy and have pointed out its inconsistency and inadequateness. It violates the fundamental requirements of scientific hypothesis; it is not consistent with itself, and it does not explain the facts. It is so full of contradictions that its opponents will have no difficulty in citing passages from the 'World Riddles' convicting the author of almost any philosophical heresy under the sun, while its defenders will be equally successful in proving by means of other quotations that the charges are unfounded. There is a great deal of truth in what von Hartmann says with respect to Haeckel's philosophy in his 'Geschichte der Metaphysik':

> Haeckel is therefore an ontological pluralist, since he conceives nature as a plurality of separate substances (atoms); a metaphysical dualist, since he assumes two metaphysical principles (force and matter) in every single substance; a phenomenal dualist, since he recognizes two different fields of phenomena (external mechanical occurrence and internal sensation and will); a hylozoist, since he ascribes life and soul to every part of matter; a philosopher of identity, since he regards one and the same kind of substances as the ground of both fields of phenomena; a cosmonomic monist, since he denies the teleological uniformity in nature and admits only causal law; and a mechanist, since he regards all causal processes as mechanical processes of material particles.*

The fact is Haeckel's philosophy is no system at all, but a conglomeration of different systems; a metaphysical pot-pourri, a thing of shreds and patches. Perhaps this is one of the reasons of its popularity —Wer vieles bringt wird jedem etwas bringen!

Haeckel's 'World Riddles' proves conclusively that no man can neglect philosophy with impunity, and justifies the existence of a discipline like philosophy. Men will philosophize, even natural scientists—that is plain—and so long as they continue to do that, it is essential that they do it well. And they can not do it well without being trained to the work. It is just as impossible for a man to ignore the history of philosophy and to attempt to originate a system without regard to the race's experiences in system-building stretching over a period of 2,500 years or more, as it is for him to accomplish anything in physics or biology without profiting by the intellectual labors of the past and present in these fields. The man who tries to construct a system of philosophy in absolute independence of the work of his predecessors can not hope to rise very far beyond the crude theories of the beginnings of civilization. Haeckel, of course, is not wholly unac-

* Vol. II., p. 456.

quainted with the history of philosophy, but his utterances usually make the impression on one that he has never done any serious work in this line, that his knowledge is largely based on hearsay, as it were. He certainly seems to be ignorant of modern psychology, otherwise he could not speak of it deprecatingly as he does. His criticisms may perhaps fit the psychology of fifty or a hundred years ago; they surely are not apt to-day. Here Haeckel appears to be fighting windmills of his own making. It is also plain that he is unfamiliar with modern epistemology and that a closer acquaintance with this subject would have saved him from falling into error and contradiction. Haeckel is fond of accusing men like Wundt, Helmholtz, Virchow, Du Bois-Reymond and others of his age, who started out as materialists and afterwards abandoned the conceptions of their younger days, of cowardice or senility or both. It is barely possible, however, that a deeper insight into the mysteries of nature and a finer appreciation of the inadequacy of the materialistic hypothesis convinced these men of the error of their ways. Haeckel prides himself on having retained the courage of his youthful convictions. I think myself that he deserves credit for saying what he really believes, but the fact that he believes what he believes is no sign to me that his friends are in their second childhood, but that Haeckel is still in his first, so far as philosophy is concerned.

EELS AND THE EEL QUESTION.

By M. C. MARSH,
U. S. COMMISSION OF FISH AND FISHERIES.

HISTORY recites an incident in which eels played the part of an executioner. The sentence a rich Roman, Vedius Pollio, passed upon his offending slaves was, 'Away to the Murænæ.' Slave-fattened eels were a Roman delicacy, and there was probably more gastronomy than justice in this edict. Ever since, and long before, for that matter, eels have occupied a unique and conspicuous place in popular interest. For the antiquity of their history, for the diversity of rôles they have played, for the many-sidedness of their career and in their importance, eels rival any group of animals below the sons of Adam.

If one were to follow eels—meaning here the common eel and not the lamprey, the *Muræna,* or the conger, which have histories of their own—backward in literature, the journey would probably reach the dawn of history. It would be difficult to say where they first entered written records, but that they have ever been the subject of curious attention is apparent. While they doubtless first engaged man's interest by way of his stomach, they were early found worthy of his intellect. Aristotle, wise man of the first European civilization, who explained all things, discoursed wisely and ponderously of eels, and the eel question may be said to have begun with him and his contemporaries. Three thousand years have passed, Aristotle is gone, but the eels and the eel question are still with us and the wise men of our century still concern themselves with both.

What is here called the eel question is one upon which the last word will not be said for some time to come. But it has changed its form and we have it upon a rather firmer foundation than that of the ancients. It began in the mystery attaching to the generation of eels. They were as the leaves of the trees for numbers; but the course of nature in reproducing other creatures each after its own kind did not seem to be exemplified in eels. Hence the mystery. 'Eel-spawn' was of the same material as a mare's nest and pigeon's milk.

The teachings on the subject were various. They were the offspring of Jove. This belief, however, originated in the humorous reflection of a Greek poet to the effect that as children of uncertain paternity were ascribed to Jupiter, he must be the progenitor of eels. They were said to be bred of the mud; of decaying bodies in the water; from dew,

of a particular sort and falling in certain places; from the transformation of horse-hairs, and from electrical disturbances. A reverend bishop once communicated to the Royal Society a contribution on the subject of the origin of eels which in substance averred that he had seen young eels on the thatching of a cottage and that the eggs were adhering to the reeds of the thatching before they were cut, and were finally hatched on the roof by the heat of the sun. Helmont, an ancient writer, is specific and gives a recipe for producing eels. Two pieces of turf with May dew upon them were to be taken and the grassy sides apposed and placed in the sun. After a few hours an 'infinite quantity of eels' were generated. Helmont doubtless felt so sure of this that he regarded trying it a superfluous inconvenience, having no use for young eels. In the 'Piscatory Eclogues' is a reference in the same strain:

> Say, canst thou tell how worms of moisture breed,
> Or pike are gendered of the pickrel weed?
> How carp without the parent seed renew
> Or slimy eels are formed of genial dew?

Aristotle wrote: 'The eel is neither male nor female and is procreated from nothing.' He explained that they were produced from the slime of their bodies, which they scraped off against the pebbles or stones or by contact with each other in their sinuous migrations. This sounds fishy to the twentieth century, but it is easy to see that to Aristotle there should be something in it. There was the slime—that was evident enough. It was purposive in amount, it gave the slipperiness to a creature which is notoriously slippery. The remarkable abundance of eels required a theory of reproduction on a grand scale. And as for their rubbing together, a mass of wriggling and intertwining eels, the well-known 'eel-ball,' suggested nothing more strongly. What more simple and, for those times, natural!

Now there is a curious mixture of stumbling truth and preposterous error in the development of the eel question from this time forward. There was another teaching concerning the source of eels. Some who examined them discovered many small worm-like creatures in their internal machinery and insisted that these were the young and were produced alive from the parent eel—that is, that the eel was viviparous. This was certainly a much more natural and credible explanation, but it was scorned by Aristotle and Aristotle was correct. He said they were not eels, but were worms, and modern observations sufficiently uphold him. Yet the contrary opinion was held by the scientists of the middle ages, and names which are written high and imperishably on the scroll of fame subscribed to it. Leeuwenhoek, the discoverer of bacteria, and the renowned Linnæus believed that eels were not spawned and hatched but were born.

This idea, entirely erroneous, was corroborated later by a correct observation. This time it was in another direction that the investigator came to grief—so slippery was the eel question. He was not examining an eel, but an eel-pout, a fish very far removed from the eel, but so resembling it externally that the ichthyologists have, for a specific name, called it *anguillaris,* eel-like. And it has been popularly known as 'mother-of-eels.' This eel-like fish is really viviparous, it produces its young alive, and they resemble small eels. The learned doctor thought he had solved the eel question. But he hadn't. To add to the confusion, another authority reviewed this work on the eel-pout and decided, being influenced by the previous real mistakes of the same nature, that the supposed young eels were only worms. This was plausible, yet he was wrong, for they were undoubtedly legitimate little eel-pouts, mistaken for little eels. Every one, it appears, who took up the question, managed from a basis of truth to reach a wrong conclusion.

Aristotle held that eels were also produced from the 'bowels of the earth,' by which he meant nothing more than common earthworms, which he curiously conceived to be thus related to Mother Earth. Other opinion maintained that eels were the offspring not of eels, but of other kinds of fishes, or of animals that were not even fishes. This heterodoxy was too much for Aristotle, but to this day is prevalent in some form among eel fishermen in various parts of the world. As for instance, that the 'aal-mutter' referred to, the eel-pout, really produces eels; that eels pair with water snakes; and in Sardinia that the well-known *Dytiscus* beetle is responsible for eels.

If these conflicting theories seem to us a ludicrous and amusing hodge-podge, it must not be forgotten that they were the wisdom of bygone days. Out of them the eel question resolved itself into a serious problem which interested the whole biological world, and to which the first talent in science addressed itself and on which voluminous and pretentious treatises appeared. Buffon, the naturalist, remarked that he considered the question of the generation of eels one of the most puzzling in natural history. Very appropriately it remained for the century of Isaac Walton to first assert that eels were not the subjects of a special dispensation for their replenishment, and that the mystery of their generation was the same mystery that envelops the rest of the kingdom of life. This not very brilliant announcement seems to have been put forth as a purely academic deduction. There were no observations in the modern sense, and the author of the 'Compleat Angler' was not particularly enthusiastic over it. He merely mentions it without subscribing, and says: 'But most men differ about their breeding,' and then after citing at some length what 'some say' and 'others say,' remarks: 'But that eels may be bred as

some worms, and some kinds of bees and wasps are, either of dew or out of the corruption of the earth, seems to be made probable by the barnacles and young goslings bred by the sun's heat and the rotten planks of an old ship, and hatched of trees.'

The passing of Aristotelianism and the revival of the sciences, in the sixteenth century, was the occasion of this renewed interest in eels. It was not, however, until the eighteenth century that sex in eels was definitely recognized. Sancassini, a surgeon of Comacchio, in Italy, visited the eel fisheries at that famous place of eels, and chancing to be struck with the appearance of a large one, his professional instinct led him to use his knife. The result caused him to send it to Vallisneri at the University of Padua, who recognized with enthusiasm the true ova and forthwith communicated this fact to the Academy at Bologna. Vallisneri has since been appropriately honored by the bestowal of his name upon a water plant well known to all—eel-grass. But the immediate effect of his announcement was an eel controversy. Eels became the burning topic of the hour among the professors, the best-known names of the time are associated with the discussion, and Bologna became the storm-center of the eel question. Another specimen similar to the first increased the agitation. But Valsalva, of anatomical fame, showed that there were certain appearances in almost any fat and well-favored eel that strongly simulated what Vallisneri had described, and in brief, hinted that the alleged eggs were globules of uninteresting adipose. An enthusiast offered a reward for an eel that should contain undoubted eggs. Of course he got it. His joy was short-lived, for a critical inspection showed that mercenary considerations had led the fisherman to fill the specimen with foreign eggs. This irreverence, and at this juncture, disturbed the seriousness of the situation and the eel question slumbered for over half a century. Then, again from Comacchio—whence emanated many of the errors and the final truth—another eel falling into initiated hands marked the crisis in the eel question. Among these privileged ones was the famous Galvani, and in grave council assembled, he agreed with the others that it was the counterpart of Vallisneri's historic eel of seventy years before, and was a precious specimen and must be sent to the naturalist Mondini. And Mondini, in a publication which is classical, first described in accurate terms the female eel, and lifted the eel question out of the uncertain field of speculation to a basis of solid fact.

Not immediately, however. Spallanzani a few years after visited the Comacchio region for the sole purpose of studying eels and reported a negative to Mondini's observations, which accordingly suffered a nearly total eclipse lasting many years. In 1850 Rathke was able to describe an eel in full roe, the first that ever came into the

hands of an investigator, the eggs of Mondini's eel being immature. This important event was the final blow that settled the sex question as far as eels are concerned. Over twenty years afterward, however, the German Fishery Association in Berlin was led by renewed interest in eels, due to the stimulus of Syrski's work on the male eel, to offer a reward of fifty marks for an eel in full roe. The eel was to be submitted to Professor Virchow, and the royal superintendent of fisheries undertook to forward the responses. It seems that about every German newspaper 'from the Rhine to the Vistula and from the Alps to the sea,' gave publicity, with a result creditable to them, but overwhelming to the royal superintendent. His delight at the popular interest in eels was succeeded by astonishment and that by horror. His postal expenses compelled him to announce that all eels and communications should be forwarded direct to Virchow. The public complied and the great German savant was obliged to cry enough and beg for mercy. People wrote and sent their specimens, parts of eels, contents of eels, thread worms from eels and above all, stories of eels and of eggs in eels, but seldom an eel intact and none in the desired condition. They usually ate the eel and sent various and often irrelevant portions of its anatomy, with a request that the fifty marks be remitted by return mail. If this prize contest had no scientific results, it contributed to the merriment of the German nation. The comic papers cartooned the incidents and announced that in the future the scientists desired only smoked eels.

To Mondini is due the credit which has largely gone to Rathke of first demonstrating sex in eels. History repeated itself as often before and since in according the honors of priority elsewhere than they belonged. However, all these observers shared in determining an important and historic phase of the eel question, which, while there are still interesting queries connected with the natural history of eels, has now merged itself with the general and special problems of biology and is no longer paramount as in the olden days.

Eels themselves, as such, are no mystery, but a familiar and commonplace factor in our economy. From the epicurean standpoint extremes meet in them—they excite a gastronomic horror in minds appropriately constituted and a peculiar delectation in the gourmand in whom suggestion is not strong enough to appeal against the keen delight of a sensitive and discriminating palate. The eel has ever occupied an extreme position. He is apt to be loathed or loved. It is characteristic of him that he never did anything by halves. What he does he does with all his might. In breeding his offspring were legion and filled the seas. In his contact with the human race, he ingratiated himself into the affections of a whole nation, or was rejected utterly.

The Greeks and Romans seem to be first in their regard for the eel, and many tales come down to us of the esteem in which he was held in their ancient times. The Romans cultivated eels, tamed them, made pets of them; and the orator, Hortensius, rival of Cicero, wept bitterly at the death of his favorite muræna. They even sacrificed their slaves to the eel ponds, a practice quite possible to men who plundered nature to serve peacocks' brains and parrots' tongues at their tables. The Egyptians are said by one account to have abhorred eels utterly, but it is certain that at one time eel-worship shows them to have also judged the eel to rank with the gods. The Scotch taboo the eel entirely, while the Hebrew race placed it under the ban which applies to scaleless creatures of the fish tribe. The conger eel is scaleless, but the common eel does not deserve this calumny, for its minute oblong scales, curiously arranged in groups instead of imbricated regularly as in the common fishes, are easily seen on careful inspection. The ancient Anglo-Saxon, on the other hand, was passionately fond of eels, which passed current as a medium of exchange. The race has always been partial to them and Londoners of to-day consume them in great quantities. Some ancient peoples used them in sacred offerings. Terracina, a seaport of Italy, being besieged by the Turks, the inhabitants vowed twenty thousand eels per annum to St. Benedict. The account relates that a 'fond memory of stewed eels' touched the saint and the siege was raised. He got his eels, and the Benedictine monks have been accustomed to render the yearly tribute to their saintly patron.

The prominence of eels among fishes is of course largely dependent upon their great abundance and almost world-wide distribution. Our common American eel is found from the Gulf of St. Lawrence to Mexico, but is absent from Hudson Bay and the Arctic Ocean and is present in the eastern Pacific only by transplantation at the hands of man. It inhabits both the sea and inland waters, but was unknown above the falls of Niagara until artificially introduced. Its natural history even yet is not as well known as would be expected. Most fishes which live alternately in fresh and salt water are anadromous, and feeling the sea their proper home migrate at certain seasons up the rivers, where they spawn in fresh waters and return to the salt until the next season. But the eel has been supposed to reverse this process, and, being at home in the sweet water, to descend to the sea to deposit the eggs, which are numbered in millions, and then die, its span of life naturally ended. The young eels resulting, driven by the impelling force of instinct, must then find their way back to the haunts of their parents. Well-known facts speak for this view. Young eels in the spring are known to ascend streams in countless numbers, and the phenomenon has long been well recognized as eel-fairs, or eel-fares.

In some regions this is an event of the spring much looked forward to. The little eels are known as elvers—a corruption of eel-fare—and are boiled and pressed into cakes—eel-cakes—which become for the time being an important article of food.

Both elvers and adults, however, are found above obstructions in the rivers which seem to make impassable barriers. It is certain that the young display the greatest persistence in climbing streams, and evidence is not wanting that to get around obstacles they leave their native element and make a land journey. The stories on this point do violence even to the somewhat lax canons which by tradition and present practice are supposed to govern the history of the tribe of fishes. There is no doubt that they can wriggle for some distance over favorable ground, as through wet grass. Albertus Magnus writes in 1545: 'The eel also comes out of the water in the night time into the fields where he can find pease, beans, and lentils.' Another writer contradicts pointedly in differing from this opinion. He says: 'They eat fish, do not come on the land and do not eat pease, but remain in the water always and are nocturnal animals.' But Bach, a Prussian naturalist, insists that eels do devastate the pea patches and avows that the peasants fish for them with the plow by cutting a furrow before daybreak, which intercepts their retreat, and that sometimes for the same purpose sand or ashes are used, which adheres or dries the slime on their bodies, making locomotion impossible. On the other hand, it is related that eels stranded by the drying of pools adjacent to larger waters have not attempted the short journey necessary to return to the main stream, and that the presence of eels far overland is to be attributed to poachers who throw them away in flight from pursuit.

It is not to be doubted that the necessity of water breathing is no bar to short overland journeys. The moisture of the grass or ground which is a necessary condition of such wanderings probably replaces somewhat for breathing purposes the natural medium which the eel leaves and to which his return can not be long delayed. Many fish can suspend respiration for quite a while without suffering injury. Concerning this habit a curious opinion is expressed by an English writer not so many years ago. He says, speaking of the eel, 'The curious air-bladders, so-called—which are really intended as reservoirs for water to moisten the gills of the fish when traveling out of the water—have been held to prove that it is properly an air-breathing creature, which occasionally, like some snakes, sojourns in the water for reasons of its own.'

The eel seems to have taken its name, and in more languages than one, from its suggestion of the snake. The Anglo-Saxon *aal* is derived from the Finnish for slimy, while the scientific name is the

Latin for snake, *Anguilla.* Many English names of places are compounded of eel—witness Elmore, Ellesmere, and Ely. Of the latter Fuller, in 'Worthies of Cambridgeshire,' has this illuminating explanation: "When the priests of this part of the country would still retain their wives in spite of whatever the pope and monks could do to the contrary, their wives and children were miraculously turned into eels, whence it had the name Ely. I consider this a lie." Like other objects of popular interest which include elements of mystery, eels are the subject of the most extravagant tales. Some of these are quite analogous to the threadbare story of the live frog found in the interior of a solid rock. A New England paper some years ago heralded that 'a live and active eel, a few days since, was dug out from a depth of five feet in the soil of Exeter, New Hampshire.' Doubtless this eel is exhumed annually. The tenacity of life of frogs and eels affords the starting point for these legends. Likewise to the voracity of eels may we credit an ancient chronicle that in England a few of them were one dark night observed to consume entirely a stack of hay. It may be in a spirit of emulation that some German carp—importation of the Government—artificially transplanted to the pond of a western farmer, came out one night and ate up the crop of buckwheat on a neighboring field. Elvers are reported to climb trees and the tale might not be incredible, provided any imaginable reason for such conduct could be assigned, for by their persistence they sometimes ascend the perpendicular barrier of a dam a short distance. This they accomplish by the partial drying of those that first essay the ascent, which therefore stick to the boards and afford a slight foothold for the next comers, which wriggle a little higher and then in turn stick fast and perish.

These stories might be multiplied *ad nauseam,* but more interesting are a few facts about the symbolic significance of the eel. His slipperiness long ago passed into a proverb. Among the pictorial writings of the Egyptians the representation of an eel held by the tail denoted 'a man vainly pursuing a fugitive object.' A Greek expression of similar import reads, 'You've an eel by the tail.' It is not so well known that an eel figures also in an emblem of quite opposite meaning—certainty instead of uncertainty. It is quite impossible to hold one in any ordinary clutch of the hand. The intervention of a fig leaf, however, makes the grasp secure, and the Egyptians depicted an eel rolled up in a fig leaf when they wished to express certainty regarding things that were *a priori* uncertain.

THE STORY OF A WORD—MAMMAL.

By Dr. THEO. GILL,
WASHINGTON D. C.

THE time for the final consideration of words commencing with M for the great English Dictionary is now very near at hand, and I venture to offer suggestions respecting one in very general use whose etymology has been misunderstood and erroneously stated in all the published English and American dictionaries; that word is mammal or mammals. I have already explained the significance of the word in a periodical devoted mainly to ornithology (*The Osprey*), but probably few readers of The Popular Science Monthly are acquainted with that magazine and the data are here given in another form, and with many additional facts.

In the great Century Dictionary, a deservedly esteemed work, and which may generally be implicitly trusted, the etymology of mammalia is given as 'NL. (sc. *animalia*), neut. pl. of LL. *mammalis* (neut. sing. as noun, *mammale*), of the breast: see *mammal,*' and, under mammal, we have '*a.* and *n.* [=OF. *mammal*=Sp. *mamal*=Pg. *mamal, mammal*=It. *mammale,* n.; < NL. *mammale,* a mammal, neut. of LL. *mammalis,* of the breast, < L. *mamma,* the breast].'

All this is misleading, if not erroneous. The name mammalia was first coined and used by Linnæus in 1758, and was formed directly from the Latin; it had nothing to do with French, Spanish, Portuguese or Italian words. The concept of which the Linnæan word is the expression is as remote from a popular notion as could well be, and even the necessity for the word (or an analogous one) can be appreciated really only by the educated or, *pro tanto,* the scientifically educated. Buffon and Pennant, for example, could not realize the reason for its use.

It is noteworthy that in the Century Dictionary even the very word that might have given the clue to the formation of mammal is cited and yet the excellent professional etymologist who worked on it was not guided into the right path. With the hint given to him, he failed to see the point. Evidently, then, the etymology is not as obvious as it might seem to be.

Often, indeed, in looking over etymologies, we have been impressed with the insufficiency of philological learning alone for the solution of knotty questions. A living knowledge of the objects named is often

requisite for a full understanding of the significance or aptness of the names.

It was one of the happiest inspirations of Linnæus to segregate all the mammiferous animals—the hairy quadrupeds, the sirenians, and the cetaceans—in a single class. No one before had appreciated the closeness of the relations of the several types, and there was no name for the new class (or concept) as there was for all the others.* A name, therefore, had to be devised. It was another happy inspiration that led Linnæus to name the class *mammalia*. Those who are familiar with the works and ratiocination, and especially the nomenclature of the great Swede, may divine his thoughts and share with him in the execution of his ideas, although he did not give eytmologies. For those 'animalia' which are animals *par excellence* he would coin a name which would recall that fact. (Animal, be it remembered, is often used in popular converse in the sense of mammal.)

The name in question was evidently made in analogy with *animalia*. In animalia, the principal component was *anima*, the 'vital principle' or animal life. (Old Nonius Marcellus well defined and contrasted the word—'animus est quo sapimus, anima qua vivimus.') The singular of the word was animal. In mammalia, the essential component is *mamma*, breast; the singular should be mammal. The terminal element (-al) was coincident with rather than derived directly from the Latin suffix (-alis) which expressed the idea of resemblance or relationship; anyway, it was used in substantive form, and the idea of possession or inclusion was involved, as in the case of animal, capital, feminal, tribunal—all well-known Latin words. In fine, a mammal is a being especially marked by, or notable for having, mammæ.

The truth embodied in the word was almost immediately appreciated by naturalists at least, and the class of mammals has been adopted ever since the Linnæan period by zoologists. Naturally the new Latin name was to some extent replaced by names in the vernacular tongues of most nations.

In the accommodating English alone the Latin word was adopted with only a change in its ending, and thus the class name *mammals* was introduced, and the singular form—*mammal*—followed as a matter of course, and by chance (or rather the genius of language) exactly coincided in *form* with the singular of the Latin word.

Not only had the name nothing to do with the alleged derivative Latin words. It was not admitted at all into the vernacular speech of

* The assertion of Owen that Aristotle fully recognized the class of mammals under the name Zootoca is without proper foundation. Long ago, in the *American Naturalist* (VII, 458), I showed that different passages in Aristotle's books negatived such a statement and that the word zootoka was not used as a substantive.

France, Spain, Portugal or Italy. The naturalists and lexicographers of those countries failed even to appreciate its etymological aptness and beauty. First, the French had to introduce a new word to correspond—mammifères or the breast-bearers. The other Latin races followed; the Spanish and the Portuguese with mamiferos, and the Italians with mammiferi. None of the words quoted in the Century Dictionary are even given as nouns in the ordinary dictionaries of those languages—not even in the great dictionary of Littré. Littré, however, has the words mammalogie, mammalogique and mammalogiste.

Of course the Germans coined a word from their vernacular—Säugethiere or suckling animals: the cognate nations imitated; the Dutch with Zoogdieren, the Swedish with Däggdjuren, and the Danes and Norwegians with Pattedyrene.

The first writer to use the English word Mammals to any extent was Doctor John Mason Good. In 'The Book of Nature' (1826), in the second lecture of the second series, 'On Zoological Systems,' he specifically introduces it. Quadrupeds is not appropriate 'and hence it has been correctly and elegantly exchanged by Linnæus, for that of *Mammalia,*' and he concludes, 'as we have no fair synonym for it in our own tongue, I shall beg leave now, as I have on various other occasions, to render *mammals.*' He repeatedly used the English form elsewhere in 'The Book.' I have been unable to find any use of the word in its singular number, however.

The singular form—mammal—has been indicated as rare or unusual. One might look through many volumes on mammals as well as on general natural history and not find it. As a matter of fact, however, it may be frequently used. Let us go, for example, into a laboratory when they are assorting a miscellaneous lot of bones gathered from some fossil ossuary. Such expressions may be heard as 'that *seems to be* a mammal bone'; 'that *is* a mammal bone'; 'that is a *mammal* bone'; '*that* is a mammal bone'—or the substantive mammal alone may be used. Further, a whale may be alluded to as a gigantic mammal or a mammal giant.

The earliest English author to use the singular form to any extent was Richard Owen. In his 'History of British Fossil Mammals and Birds' (1846), for example, he alluded to a mastodon as 'this rare British Fossil Mammal' (p. xxii), and asserted that he knew 'of no other extinct genus of mammal which was so cosmopolitan as the mastodon' (p. xlii); he said that 'the *Myrmecobius* is an insectivorous mammal, and also marsupial' (p. 40), and he claimed, conditionally, that 'the *Meles taxus* is the oldest known species of mammal now living on the face of the earth' (p. 111).

Even the word in plural form was grudgingly admitted. The Latin

form mammalia was long preferred. The chief translators of the 'Règne Animal' rendered mammifères by mammalia; Blyth alone substituted mammalians in its place. Owen, in the work already cited in which mammals was used on the title-page, employed mammalia in the text more frequently than mammals, and yet he used the English form more than any of his contemporaries. Popular as well as scientific writers avoided the English word as one alien to the genius of the language. Some preferred the word mammifers when they would use an anglicized term.

By reason of the general ignorance of the etymology of the word mammalia, and the dislike of it, on account of the misapprehension that it was an imperfect or clipped word, the early French naturalists devised one of their own—mammifères—and this early took root and has been universally adopted by French writers. It was to some extent adopted by English writers of the first half of the century under the form mammifers. Robert Chambers, in his anonymous 'Vestiges of Creation,' frequently used it and Hugh Miller, in his antidotes to the heresy of the Vestiges, sometimes did. Miller, in his 'Old Red Sandstone' (1841), also accepted the singular form in his statement (Chapter IV.) that 'the mammifer takes precedence of the bird, the bird of the reptile, the reptile of the fish.' The use of the word, nevertheless, was never general. The derivative adjective, however, was much more frequently adopted for a time.

Lyell, in his 'Principles of Geology,' almost invariably used the word mammalia, but accepted the adjective mammiferous instead of mammalian and even of mammaliferous. (He admitted mammifers in his 'Glossary,' but did not otherwise use it.) This, naturally, was an example which others followed. It was not until the first half of the century had been past for some time that the English word came generally into use.

The science which treats of mammals had to be named. Mammalogy was naturally thought of, but many objected to it. The French, who would not tolerate mammal or mammaux, although they had no objection to the analogous animal and animaux, on the whole took kindly to mammalogie or mammologie. Substitutes, it is true, were offered; Desmarest proposed mastologie and De Blainville mastozoologie and the latter was admitted by Littré in his great dictionary, but they did not secure a permanent foothold and mammalogie is the term now generally used.

The objection to mammalogy was and is that it is a hybrid and also a badly compounded and clipped word. It is formed of the Latin mamma (a breast or teat) and the Greek λόγος; the true meaning is a discourse on breasts rather than breast-bearing animals. Greek nouns also generally have the vowel *o* rather than *a* before the second

component. Consequently suggestions were made to correct the word to mammology if not mammalology. Others would compound a name of two Greek constituents (*θήρ*, a wild beast, and *λόγος*). Therology was the result. Dr. John D. Godman, in his 'American Natural History' (1824), entitled the first (and only published part) 'Mastology,' thus borrowing a word first used by Desmarest. The writer of the long article on mammalia for the Edinburgh Encyclopædia (1819) coined the word Mazology (*'μαζος*, a breast, and *λόγος*, discourse'). None of these words has found general admission into the language. Notwithstanding the philological objections, mammalogy of late years has been generally accepted and general consensus establishes its right of being.

I have derived the terminal form of words ending in -ology from *λόγος* rather than *λογία*, which latter has sometimes been given, because the only Greek word *λογία* (occurring in the first Epistle to the Corinthians, 16: 1, 2) means 'a collection for the poor,' and therefore *λογία* is misleading and has misled several to my knowledge. The Greek words dikologia, etymologia, philologia and theologia of course are good precedents for the English words ending in -ology and consequently we may use, as a suffix, *-λογία* (but not simply *λογία*) in explanation of the etymology.

Supplementary Note.

While reading the proof of the preceding article I found reason to fear that, through my desire to be concise and not discursive, I might give a misleading idea of the originality of Linnæus. The concept of the class of Mammals did not spring Minerva-like from the head of the Swede, but the great English naturalist of the seventeenth century (John Ray), to whom Linnæus owed so much, was suggestive in this as in other cases. Ray, in his ' Synopsis Methodica Animalium Quadrupedum et Serpentini Generis' (1693, p. 53), gave an 'Animalium Tabula generalis' in which he bracketed the terrestrial or quadruped mammals with the aquatic as 'Vivipara,' and contrasted them with the 'Ovipara' or 'Aves.' The Vivipara are exactly coextensive with Mammalia but the word vivipara was used as an adjective and not as a noun. Linnæus did not catch up with this concept till 1758 when he advanced beyond it by recognizing the group as a class and giving it an apt name. To go farther into details is tempting, but would be out of place here.

A YEAR OF WEATHER AND TRADE IN THE UNITED STATES.

By Professor ROBERT DeC. WARD,
HARVARD UNIVERSITY.

THAT weather conditions affect trade and industry has long been known, but few studies of these relations have yet been made.* The hope of being able to determine, in a somewhat critical way, the dependence of trade and industry in the United States upon the general weather conditions from week to week, has induced the writer to give some attention to this subject for a year past. The sources of information have been the *Climate and Crop Bulletins,* and the *Monthly Weather Review,* of the Weather Bureau, and the well-known trade journals, *Bradstreet's* and *R. G. Dun and Co.'s Review.* The Weather Bureau publications emphasize the meteorological side alone; the two journals last named aim to present a true statement of trade conditions without any special prejudice in favor of meteorological controls.

The first summer month of 1901† began with decidedly cool weather east of the Mississippi River, and heavy rains in many eastern districts. This unseasonable weather was the key of the trade situation. Retail trade throughout the east was interfered with by the 'lack of sunny weather'; the growth of crops was retarded, and cotton and cereals were high. Manufacturers of umbrellas, rain clothing, rubbers and heavy footwear alone reported 'an exceptional demand.'

The second week of June was, on the whole, more favorable. In the east, where the temperatures were more nearly normal, there was an improved retail demand for summer wearing apparel, and this was also true of the northwest, where needed rains had 'quieted apprehensions as to the spring-wheat outlook.' The stimulation in trade in summer goods led to increased orders for fall merchandise. Dairy and garden products fell in price, as production increased with warmer weather. On the Pacific coast, the third week of June averaged decidedly cool, and trade was retarded in consequence. At a number of cities situated in a district where the average daily temperature *excess* was 3°–6°, the ' warmer weather created a demand for *summer* goods,'

* A noteworthy article in this connection, 'The Influence of Rainfall on Commerce and Politics,' by H. H. Clayton, appeared in the Popular Science Monthly for December, 1901, pp. 158–165.

† This investigation includes the period June, 1901—June, 1902.

while over the Plateau the average daily *deficiency* of temperature was 6°–11°, and there were *unfavorable* effects of the *cool* weather. These are interesting examples as showing, in degrees, what excess or deficiency of temperature stimulated or depressed trade in this particular case. In the Middle South Atlantic States, where there were exceptionally heavy rains, corn suffered from lack of cultivation, and trade was checked.

During the latter part of June, and in July, large sections of the United States east of the Rocky Mountains suffered from prolonged drought. Record-breaking temperatures were observed at a large number of stations, readings of 100° and above occurring in many places for several days in succession during part of the month. The daily temperature excess frequently reached 5°–10°, or more. During this long spell of hot weather the rainfall was ma ' edly deficient over many sections east of the Rocky Mountains, and hence there resulted a drought of far-reaching extent. About the midde of July, corn began to suffer severely. Locally, some damage was done to wheat and to oats, while cotton was also injured over considerable sections of the South. Occasional local rains helped to make good part of the damage to corn and cotton. The chief interest, so far as crops were concerned, centered in the condition of corn.

The first effect of the extreme heat, and one that lasted through July, was a marked stimulation of retail trade in summer clothing of all kinds, straw hats, sporting goods, and the like. The continuance of the heat over much of the country had the effect of carrying the sale of summer goods beyond the usual time. Another effect of the hot weather—and this an unfavorable one—was the curtailment of almost all branches of trade other than that in summer goods. A report from Boston, to the effect that 'buyers were few, and only necessities prompted purchases,' puts the case clearly enough. The decrease in 'shopping' led to an increase in orders by mail. The intense heat was, however, not necessarily adverse to general retail trade, provided crop prospects were favorable. This was clearly brought out in such reports as one from St. Louis, where trade 'was sustained by the result of the wheat harvest.' On the other hand, trade may not respond immediately, even when crop prospects are bright, for when the weather is fine, and farmers are busy in the fields, they have no time to go to town to trade.

The heat of the first week of July 'caused a practical suspension of industrial activity in many cities.' Numerous prostrations from heat caused humane employers to close their mills during the most distressing hours, thus somewhat restricting the output. In regard to the effect of the weather upon the steel-workers' strike in Pittsburgh, one of the trade journals reports that the striking employees were 'mostly content to take a rest during the hot weather,' and consequently were not so anxious that a settlement should be reached.

During the second week in July, business was reported as of a 'midsummer character,' *i. e.*, normal, in the east, and here the temperatures for the week were nearly, or even slightly below, normal. The statement from Louisville is representative: 'A few recent days of nominal summer weather have given a spurt to retail trade.'

The third week of the heat and drought affected not only the trade of that particular week, but led to the cancellation of many orders previously given. These cancellations came from the drought-stricken districts, and were naturally a disturbing factor in the trade situation in many Western and Southern cities.

The week ending July 22 brought local showers over portions of the drought-stricken districts, and although these showers were in most cases but scattering, there was a noticeable improvement in crop outlook and business in the sections where the rains fell. A characteristic report from St. Louis (July 19) stated emphatically that 'the business situation hinged upon the question of rain.' During the week ending July 29 also, 'advices of lower temperature and moderate rains came as a great relief to business throughout the country.'

The cattle, meat, dairy and produce markets all showed marked effects of the excessively hot weather. At the very outset, the perishable nature of butter and eggs, and the shortened milk supply, caused a rise in price, which was well maintained. A number of sugar-of-milk factories shut down. Fruits and vegetables became scarce, and advanced in price. Consequently there was a great demand for canned goods, the price of which at once tended upward. This demand continued strong for many weeks, and had it not been for the drought, the year 1901 would have been a poor one for packers and jobbers of canned goods, because they had carried over a very heavy supply from the previous season. The decreased sales of fresh meat during the heated term caused an advance in the price of hides at Boston.

The drought and consequent lack of pasturage in the southwest led to record-breaking shipments of cattle and hogs to market at Kansas City, the receipts for the month exceeding those for July, 1900, by 263,000 head. This extraordinary rush of live stock resulted in an over-supply of young cattle. Buyers dictated prices. The situation in the hide market was much complicated. Tanners were able to hold down the price of hides. Smaller requirements in the way of corn for fodder, and restricted subsequent arrivals of cattle, were expected.

Of all the economic aspects of the heat and drought of July, the greatest interest attaches to the prices of stocks and cereals. During the second week of July, reports of heavy damage to corn and oats in the Missouri valley belt caused the market to 'break badly.' The heaviest declines came in the stocks of railroads which were likely to be affected

by a partial failure of the corn crop in the southwest, such as the Atchison and the Rock Island. Reports that rain was likely to fall in Kansas caused a rally from the low figures. During the week ending July 20, in spite of the short corn crop, the large wheat yield made it evident that the cereal production of the west as a whole would furnish abundant traffic for the railroads. The appearance of rain in parts of the west led to considerable repurchasing of railroad stocks by capitalists who had sold Granger and Pacific stocks on the unfavorable crop outlook of two weeks before. Atchison common stock rose ten points; Rock Island was a very strong feature, ' and the Grangers generally responded promptly to the improvement in the corn-crop outlook.'

The highest non-corner prices for corn since 1894 were paid during the week ending July 27. The damage to crops in the territory tributary to the Union Pacific in Kansas and Nebraska 'raised strong doubts as to the possibility of any increase in the four per cent. dividend on the common stock.' Union Pacific was one of the most prominent stocks in volume of transactions, and sold down very sharply from 104½ to 93¼. St. Paul fell from 164 to 152½, and the other Grangers were similarly affected.

Under the influence of the extreme heat, summer travel was reported as the heaviest in years; this gave the transportation interests large earnings, while the hotels and stores in sections frequented by summer visitors did an excellent business. Much money was left in summer resorts, and collections there were consequently good during succeeding months. While the carriage of wheat and of live-stock by the Granger roads during July was very heavy, the shipments of oats and corn fell off sharply, the movement of corn to seaboard points declining 72 per cent. as compared with that in July, 1900. Foreign commerce was seriously affected. In Scotland, Russian and Algerian maize practically supplanted American corn. The heat interfered with building, so trade in paints, oils and other building requisites was checked. Meats were in less demand, and wholesalers in some cases reduced prices in order to move fresh meats in storage. The hot weather was unfavorable for the curing of fish. The consumption of milk increased, and there was a scarcity in many cities. The demand for ice was so great that there was difficulty in chartering vessels in which to ship ice from Maine.

After about a month of intense heat and of drought, lower temperatures and good rains were experienced over most of the drought-stricken districts. The relief to trade was immediate and general. In the great corn States, more than usual of the year's crop had been planted late, and this late corn improved greatly, although early corn was practically ruined. A large spring-wheat crop was assured by the rains. Cotton-crop conditions at the south were also improved, and

trade reports were consequently more cheerful from southern cities. An abundance of forage supplies was now certain. The western farmers regained courage; the rush of cattle and hogs to market stopped. The pressure in this line being removed, many of the cattle which had been sent to market were not slaughtered, but were kept to be fattened. Hence a great accumulation of skins was no longer expected. The most unfavorable trade reports naturally came from the central west and southwest, where the loss from drought had been greatest. Kansas City, however, reported that anxiety had been followed by 'a feeling of relief and hopefulness.' Cancellations stopped, as country merchants took new courage. July bank clearings at Kansas City were the largest on record, because of the heavy receipts of cattle and hogs, but for the country as a whole bank clearings for July were adversely affected by the heat and drought. Fluctuations in corn continued, as conflicting reports of greater or less loss were given currency. Good spring-wheat reports, and liberal arrivals at interior cities, weakened prices of that staple. Cotton was weaker, owing to the arrival of needed rains.

While the tide of trade turned distinctly after the drought, and there was a generally cheerful tone everywhere on account of the seasonable weather and favorable crop outlook, the heat and dry weather continued to affect trade in various ways for many weeks. The shortage in corn and potatoes led to an increased demand for rice, and trade in canned goods and dried vegetables was stimulated by the scarcity of fresh vegetables and fruit. In the southwest, especially, the scarcity of fruit and vegetables gave the local commission houses a large business in fruit and produce. Meats and dairy products remained high, 'partly owing to the fear of smaller supplies later in the season, due to the early marketing of young and unfattened stock,' and partly because of the high price of corn. As late as September 7 nearly all the lumber mills in Oregon closed down on account of the unsatisfactory condition of the market resulting from the crop shortage in eastern sections.

The special feature of the week ending August 17 was the effect upon southern trade of a West India hurricane, which gave very heavy rains over some of the southern states, and on the Louisiana coast alone did damage to growing crops, chiefly rice, estimated at $1,000,000.

At the end of the second week in September, with the coming of cooler weather, summer travel fell off decidedly in Maine and elsewhere, and retail trade in many of the larger cities improved with the return of the summer absentees.

Abnormally cool weather, with local frosts, prevailed east of the Rocky Mountains during the week ending September 21. Corn, cotton and dairy products advanced in consequence. The immediate effect of these lower temperatures was to stimulate the demand for fall and

winter supplies at cities situated in the region of maximum temperature deficiency. Coal and stoves became active. While the greater part of the country was unusually cool, the North Pacific coast averaged slightly warmer than usual. And we note that retail trade at Portland, Ore., was quiet because of the 'continuance of summer weather.' Railroad earnings in September were adversely affected by the lessened grain movement in the west, and by the damage done by the hurricane on some of the southern railroads.

October was warmer and drier than usual throughout nearly the whole country. This being a month when cool weather is needed for 'seasonable trade,' the keynote of the month may be found in the statement that where cool, trade conditions were good, and coal, furs, winter clothing, stoves, liquors, etc., were active, and where abnormally warm, retail merchandise distribution was retarded, but the handling of crops, and outdoor work, including building, were helped. The later on in October the warm weather continued, the more unfavorable were its effects on 'seasonable trade.' Towards the end of the month, hot weather interfered with the 'kill' of cattle, and caused a scant offering of hides; hence prices held well. The shortage in freight cars, which was a conspicuous feature throughout October and the following months, did not cause any serious inconvenience in the case of coal, because of a small demand due to the high temperature. Failures for October showed an increase in the south, where the backward state of cotton checked trade and delayed collections.

The colder weather of November stimulated trade in heavy clothing, shoes and groceries, and caused an increased demand for oysters and for coal, but rubber footwear was quiet throughout the month, owing to dry weather. The cold weather also started the tide of winter travel to California. Eggs rose in price. At the south, the backward cotton crop was a check to trade. A warm wave during the second week of November checked retail demand in the lower Mississippi Valley, and thence east to the Atlantic Ocean, the depression in trade accompanying the warm wave in its eastward progress. The car shortage in the east, already referred to, was complicated by the unusual movement of corn and oats west to the drought-stricken states, but it was seen that lower temperatures would relieve the situation by stopping lake transportation, and restoring thousands of cars to inland traffic. Abundance of snow in Maine at the end of November facilitated lumbering and caused a demand for sleighs, and distinctly colder weather put the market for anthracite on a firm basis.

Between the 14th and 19th of December, the minimum temperature records for the second decade of that month were broken in all districts from the South Atlantic and Gulf coasts northwest to the upper

Mississippi and Missouri valleys, including the middle Rocky Mountain slope and the Ohio Valley. There were also very heavy rains in eastern sections about the middle of the month. The exceptionally cold weather immediately stimulated retail trade in winter goods in many places. Eggs, poultry and potatoes advanced. In the New York stock market, the cold gave strength to the anthracite group of railroads, because it was certain that coal consumption would increase at once, but floods in the mining regions of Pennsylvania curtailed the coal supply, interfered with transportation, and cut down railroad earnings. Building was interfered with by the cold, and the receipts of wheat fell off because of the interruption of railroad traffic. As regards railroad earnings for 1901 as a whole, the southwestern roads were unfavorably affected by the poor corn crop, and the southern roads by the late cotton crop.

January was mild and generally dry, especially during the first two decades, but closed with ample snow covering over the winter-wheat states. Retail distribution of heavy clothing, boots and shoes, and rubber goods, was checked by the mild weather, and the loss of snow retarded lumber operations. The high temperature, however, stimulated the demand for spring goods at wholesale, and building, and the demand for building materials, were active. The snows of the end of the month were favorable for winter-wheat, and furnished water for cattle, and therefore improved the tone of the stock market, especially in the case of northwestern securities. But these same snows interfered with transportation interests and with trade, except that in winter clothing and rubber footwear. The future, as one trade journal had it, profited at the expense of the present.

During the first two weeks of February, snow obstructed traffic by railroads, cutting down receipts of live stock, corn, wheat and coal, and causing the banking of mills and furnaces because of lack of coal. Country roads were blocked, and country merchants were kept away from town. This increased orders by mail. Farmers could not reach their banks, and this interfered with the free circulation of money. During the second week of February, it was reported that as a result of the long drought in the southwest, water was scarce, and railroads had to haul it a hundred miles in places. At St. Louis, 'local retail trade was decreased by reason of the dangers of ice-covered sidewalks and streets.' Loaded car movement at St. Louis and Indianapolis was below that for preceding years, snow blockades throughout the west and north having compelled the railroads to reduce the number of cars per train. There resulted a notable decrease in Atlantic exports of flour, and a crowding of side-tracks at division points with loaded cars waiting to be moved.

Heavy snow and sleet storms during the last week of February did great damage to telegraph and telephone wires in some of the large eastern cities. Mail and transportation facilities were seriously interrupted. Stock exchange transactions in New York and other cities were limited to local orders, and this restricted sales. Trade in overshoes and rubbers was larger during this week than for the two preceding months. Floods and high water interfered with iron and steel production, with transportation interests, and with the coal output. The crippling of the railroads, which caused an unusual demand for structural materials, was noticed by 'the street,' but had little effect except upon the anthracite stocks, although March earnings were cut down by the February snowstorms.

Mild weather in the northwest early in March, and later on in the east, prevented loggers from getting out their entire cut, and led to the breaking up of many camps. By the middle of March the sidetracks were being cleared of the cars stalled there by the February storms; shut-down mills were running again; the advent of spring weather acted as an important stimulant to most lines of trade and industry; butter and eggs were lower; the demand for building materials increased, and weather reports regarding wheat began to claim careful attention. According to one trade journal, ' each cloud is telegraphed as heralding copious rains, while a ray of sunshine means drought.' The injury to crops during the summer of 1901 made stocks peculiarly sensitive to indications of drought. During the week ending March 22, the most severe cold wave and snowstorm of the month caused cattle losses in Dakota which were estimated at 2–5 per cent. Milder weather soon followed, and somewhat relieved the strain on the coal trade.

The opening of lake navigation in April began greatly to facilitate traffic at the north. The week ending April 26 was one of contrasts. Heavy snows interfered with farm work in Montana, the Dakotas and Minnesota, while hot winds in the central valleys and middle Atlantic States brought unusually high maximum temperatures, which were detrimental to crops. In consequence, weather reports had more influence than usual in shaping the prices of cereals, which advanced until reports of general rains in the southwest caused a decline of 2 cents a bushel on wheat. The 'versatile' weather of the week produced erratic fluctuations in the security and cereal markets.

Much was heard during the spring of 1902 about the high price of beef and of other meats. These high prices were at least partly due to the large cattle receipts of the preceding fall, there being little inducement to carry stock through the winter, with corn at 60 cents a bushel instead of 20 or 30 cents. The high price of beef led to the

consumption of pork products, poultry, etc., which depleted supplies and raised prices in these lines. The natural consequence of a short corn supply was thus seen to be higher prices for cattle and hogs.

During the first week of May, nearly the entire country east of the Rocky Mountains had highly favorable temperature conditions, but the unsettled crop conditions in the southwest were the reason of a failure to give much support to Missouri Pacific and Atchison stocks. Throughout May unusually heavy rains in the northwest retarded farm work and interfered with trade there. During the week ending May 24, Chicago, where the average daily temperature excess was 12°, reports 'the feature in the drug trade was the increased call for soda-water supplies caused by the hot weather.' The coal strike, which had begun to attract considerable attention, was much less of a burden on the general public than it would have been if the weather had been cooler.

The examples above given, which are but a few of those that are available, show clearly enough something of the effects of the weather upon trade, industry and financial transactions. No attempt has been made to estimate the financial loss or gain due to the weather conditions of any single week, or month, or of the year as a whole. Approximate estimates of this kind can be, and often are, made in individual cases, as in the case of the damage done by some storm to crops or to transportation interests in some particular section, or in that of the money value of one rain to cereals, fruits and vegetables in a time of drought. But it has seemed to the writer that no useful purpose could be served by attempting, in the present article, to make any such rough estimates as are alone possible.

The principal object of this investigation was to ascertain, if possible, whether the relation between weather and trade could be expressed in fairly exact meteorological terms. In order to study this subject, the Weather Bureau charts showing the weekly (or, in winter, the monthly) temperatures and precipitation, and the departures from the normal temperatures and precipitation were used. On these several charts the stations were located at which trade was reported as having been affected by the weather. Cities where trade had showed effects which were ascribed to the temperature were noted on the charts showing departures from the normal temperature, a sign being used in each case to show whether the effect was beneficial or otherwise. Cities where the reports indicated favorable or unfavorable effects of precipitation were noted in like manner, on the charts showing the departures from the normal precipitation. In some weeks there was found an extraordinary agreement, the good effects of 'seasonable' weather upon trade being found at cities situated within, or close to, districts of normal temperature or precipitation, while the unfavorable effects of ex-

cessive or deficient temperatures were indicated at cities within districts of too high or too low temperature, respectively. Similarly, the depressing effects upon trade of too much, or too little, precipitation were found in those portions of the country where there had been an excess or a deficiency of rainfall. So close were these relations in some weeks that it was possible to state in degrees, or in inches, the amount of the excess or deficiency of temperature or of rainfall which were needed to stimulate or to depress trade (*e. g.*, the third week in June; and the weeks ending September 21 and April 14). So close an agreement is, however, exceptional. A careful study for the year in question of all the trade reports in which mention was made of weather control, and a close comparison of these reports with the temperature and rainfall charts, failed to give any such exact results as were hoped for.

The final outcome of this consideration may be briefly stated as follows: As the result of the experience of many years, trade is in a condition of such very close and delicate adjustment to the average weather of any particular month, or even week, that 'seasonable,' *i. e.*, normal weather, other things being equal, usually means 'seasonable' trade. The case is not unlike that of a row of card houses which, when left undisturbed, *i. e.*, under normal conditions, stand, but when interfered with by any unexpected or abnormal influence, fall down. Thus, when meteorological conditions are unseasonable, trade at once reflects the change, and suffers. Trade is, however, subject to many and widely-varying controls; hence the problem of the particular controls which affect it in any one week is a very complex one, and the key is not always, or sometimes even at all, to be found in local weather conditions. The trade of a city is often largely dependent upon orders coming from a distance. Hence, although the weather in the city may be unfavorable, and local trade depressed, orders from the tributary district may suffice to overcome this depression, and keep trade up to its usual standard, and *vice versa*. Again, while seasonable weather promotes active trade among the inhabitants of a city, the farmers round about may take advantage of this opportunity to work in their fields, and trade in the country districts suffers because the farmers are too busy to make purchases. Furthermore, the relation between temperature and precipitation on the one hand, and crops on the other (and hence, indirectly, the control of weather over trade) cannot be expressed in any simple way. This is partly because the effect of the weather of any one week upon crops, and upon trade, depends largely on the weather of the preceding weeks. Thus, if there has been enough rain, high, or even unusually high, temperatures may be needed to promote the growth of crops, while on the other hand, if the rainfall has been deficient, high temperatures may be very injurious. The proper distribution, in time and in amount, of temperature and precipitation in their relation to crops is a subject which itself still needs much careful study.

MENTAL AND MORAL HEREDITY IN ROYALTY. II.

BY FREDERICK ADAMS WOODS, M. D.,
HARVARD UNIVERSITY.

Evidence from the House of Hohenzollern in Prussia.

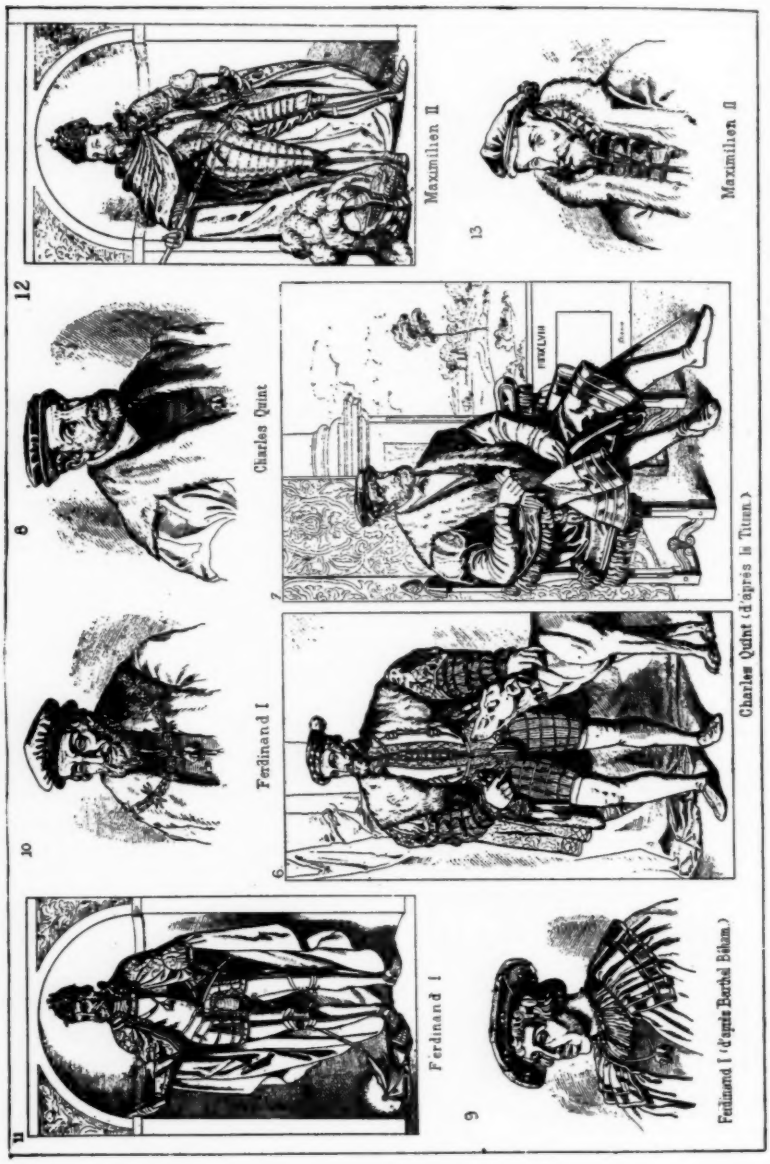
Here we find a very different condition. Let us begin with the founder of the family's influence, Frederick William, the Great Elector of Brandenburg. The great elector (1620–1688) was a man of the highest attainment and force of character. He received his country in a very desolate condition and accomplished the greatest results with the least resources. He was one of the ablest men in Germany in his time. On looking up his pedigree one finds his father a weak scion of a family not then illustrious, his mother not much above mediocrity, but a granddaughter of William the Silent.

There is every reason to believe that the great Elector was one of numerous geniuses descended from William the Silent, even if he did stand as far away from him as a great grandson. He was a first cousin of the famous Prince Rupert, and his two sisters were Sophia, Duchess of Brunswick (10), and Elizabeth of Palatine (9), a very profound intellect. This relationship was by the way of Frederick IV. of Palatine, who had married a daughter of William the Silent, by Anne, a daughter of Maurice of Saxony, a celebrated general.

Every union from now on to Frederick the Great brings in again the brilliant strain. Frederick William, the Great Elector, married a daughter of Frederick Henry, the distinguished stateholder (8). She was granddaughter of William the Silent (10), and great granddaughter of Caspard de Coligny, the great admiral of France (10). Their son, Frederick I. of Prussia, showed none of the genius, but he married a sister of George I., and therefore a daughter of the same great Duchess of Brunswick (10). Her father also was distinguished and ranks in 7 (Ernest Augustus, Elector of Hanover).

This queen of Frederick I. was Sophia Charlotte. She had high ideals and an important influence over political actions. She was really profoundly interested in astronomy, prehistoric remains and moral philosophy, and formed a warm friendship with Leibnitz. Von Heineman says she was generally called the 'Philosophical Queen.' She is placed in grade 8. Their only son was Frederick William I., a most remarkable character. He was not very intellectual and especially despised literature, but was a man of iron will with great ability in

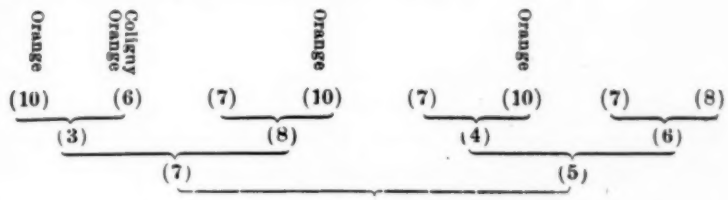
this line, and succeeded in carrying out his strange determinations. He it was who collected the giant army of Prussia. In his avariciousness and bigotry, as well as in his facial features, he so much resembled his



cousins the Guelphs (a house of Hanover), of England, that one is inclined to believe he got them all from the same source. He is placed in grade 7. His queen was an amiable and virtuous woman. She

was his own cousin and by the Orange branch. Thus now this great stock is repeated four times in the pedigree. Besides this we have four other great grandparents of high standing.

Thus the pedigree stands for intellect:



It will be noticed that only two are below mediocrity. From this remarkable union were produced, out of ten children, five of the most illustrious persons contained in this study. These were Frederick the Great (10). Henry, his almost equally great brother* (9). Charlotte, Duchess of Brunswick (8), had a remarkable mind, literary tastes and fine character. Wraxall said of her that he scarcely ever met a woman in any walk of life who possessed an understanding more enlarged and cultivated. Amelia (9), 'endowments of mind said to have been extraordinary,' had a remarkable talent for music† and Louisa Ulrica, Queen of Sweden (10), was called the ' Minerva of the North.' The other five included Frederica Sophia, of Baireuth, whose memoirs are considered very interesting. These other grades are 7, 5, 5, 3.

Frederick the Great also had a number of nephews and one niece who were very richly endowed mentally. As some of these would escape mention elsewhere they are here enumerated:

1. Gustavus II. of Sweden (9).
2. Sophia Albertina, his sister (8).
3. Augustus Frederick of Prussia (8); reputed the first artillery officer in the Prussian army.
4. Louis, a son of Ferdinand of Prussia (8); distinguished talents.
5. Amelia Duchess of Saxe-Weimar (9); the distinguished patron of genius, of Wieland, Herder, Goethe, etc.
6. Charles William Ferdinand (8) of Brunswick; celebrated commander.'*
7. William Adolphus (8) of Brunswick; generally brilliant, and an author.

Such a union of high talents, found here about Frederick the Great, is certainly remarkable and bears out Galton's idea that of all great men, the greatest commanders have the greatest number of eminent relations.

Frederick the Great had in the first degree of relationship, in spite of having no direct descendants, one in 10, two in 9 and one in 8. In second degree two in 9, five in 8. Three of his great-

* Lippincott.

† Wraxall, 'Berlin Mem.,' Vol. I., pp. 209, 294.

CHARLES V.

MAXIMILIAN II.

MARY, QUEEN OF HUNGARY.

MARIA, DAUGHTER OF FERDINAND I.

grandparents were in grade 10. It is very easy to account for this high wave of intellect, for in the first place among the sixty-two ancestors who lie in five degrees of remoteness, one finds only two in a grade below 4 and only one below 5. These were Frederick I. of Prussia and George William of Brunswick, who were in 3; both lie remote. This alone is remarkable, and I doubt if the same would be true of any other chart, or indeed of any other family.

In the second place one sees the House of Orange four times in the fifth generation. This of itself would probably create only a small effect since this entire generation is considered to have only 3⅛ per cent. of influence, but we see here a fortunate selection of the best, and four of its greatest descendants are found among the third degree of remoteness, and one in the second degree. Then the remaining part of the pedigree is filled in with what is best in the House of Brunswick, together with Elenora d'Olbrenze, a remarkable character.* She was of a good Dutch Huguenot family.

Among the forty included in this group (all ancestors of Frederick the Great to third degree, with nieces and nephews) we find five in 10, four in 9, six in 8, seven in 7, or nine of these forty are geniuses 9 or 10; and 22 are high in the talent class. There is a strong literary and musical bent among the descendants, and hereditary influence can be traced through both the mother and paternal grandmother of Frederick the Great, straight back to the House of Orange, from which it probably came. This is in spite of the fact that Frederick's father was entirely hostile to literature. The bent appeared decidedly in five of the ten. In the others it seems to have been absent. The pedigree calls for about half of them to show this imaginative type of mind, if we couple to the pedigree this idea: that strong mental characteristics do not freely blend, but tend to jump about, and, if appearing at all, appear in almost full force in those who inherit them in any conspicuous degree.

Whatsoever in Frederick the Great's fraternity environment would not properly account for either the appearance of the artistic taste or the fact only half showed it. This literary bent should be compared with Hanover, where eighty-seven persons show only four authors and these are every one of them in the extreme background and consequently do not influence the House itself. Among the House of Hanover a number of the princes were fond of study but none were authors.

Regarding the moral side among the Hohenzollerns, there were only a few who fell short. It corresponds perfectly in a general way with the pedigree. It is noteworthy that here as in Hanover no atrocious and violent characters appeared in the family, nor were any

* See Wilkins, 'Love of an Uncrowned Queen.'

MARIA, DAUGHTER OF CHARLES V.

ALBERT, SON OF MAXIMILIAN II.

LOUIS XIII.

PHILIPPVS III DEI GRATIA
HISPANIARVM ET INDIARVM REX
Philippus der III. by der Gratien
Gods Coninck van Hispaignen ende
Indien etc.

PHILIP III.

CHARLES III.

introduced in the pedigree. In this respect these countries should be compared with Russia, Spain, France and Italy.

Frederick the Great and his brother Henry left no descendants. In the next generation the great qualities died out in the house, because only two of the males had heirs and these were not the gifted members of the family. One, William Augustus, was weak and fond of pleasure, and was the son who resembled his grandfather, Frederick I. He married Louisa, a daughter of Ferdinand Albert, of Brunswick, an insipid woman of no gifts, with an ancestry virtuous and literary, but not talented politically.* They had a son, Frederick William II., and a daughter; the son, who had the best of education and example, was a virtuous man of average capacity, but timid and irresolute. As Frederick William II., who was *not* brilliant, married a woman below the average capacity and of a mediocre family, by the next generation all brilliancy was removed to one great-great-grandparent, out of the sixteen the children had, and to eight of the thirty-two great-great-great-grandparents; which according to Galton would be a factor of extremely small value; so it is not surprising that it never came out again in this line, unless Wilhelm der Grosse and the present Kaiser be equal to them and represent extreme reversion. Their abilities are probably derived from fresh combinations.

Among the collaterals similar dilution, or lack of any issue at all, can be shown. Thus one of the greatest strains of intellect the world has ever seen finally disappeared. Quite unconsciously on their part it was formed. Its formation appears to be due to a remarkable combination of ingredients of blood, three sources of the best from the great House of Orange were united with the Great Elector of Brandenburg, who probably himself received his genius from the house of Orange. Its disappearance might well have been due to dilution in some branches, to accident or sterility in others. Probably the only strain in modern times, in royalty or out, that can show such a quantity of eminent relationship, and of such a high degree, is the same region about William the Silent that we have shown we consider the origin of this. The relation of this blood to the course of Prussian, German and even to the world's history should not be overlooked.

If it is accepted that these characters were what they were owing largely to heredity, then it follows that Prussia's rise under the Great Elector, her growth under Frederick William I.'s vigorous policy, and subsequent greater growth under Frederick II., together with the seven years' war, must, since historians all ascribe great influence to these sovereigns, find their ultimate explanation in these charts of descent. The theories of heredity appear to be very nearly satisfied. If we con-

* See Brunswick.

FERDINAND II.

FERDINAND III.

LEOPOLD I.

CHARLES II.

sider that opportunities or the times were the chief causes, we must have a wonderful knowledge of all the intricate effects of this medium in order to explain the character in this way. The theory of chances seems here to be in danger, while the theory of chances can be shown to be pretty well satisfied by the laws of heredity.

The Hapsburg Lip.

The accompanying illustrations show one of the best known and most conspicuous facial peculiarities among the royal families, the great swollen protruding lip of the Hapsburgs which can be traced with its varying degrees of intensification through no less than eighteen generations, coming out in at least forty-one of the various descendants.

Its first appearance, according to history, was in Cymburga, who was born in the last part of the fourteeenth century, and became the wife of Ernst, the second patriarch of the House of Hapsburg.* In its latest manifestation it appears at the present day with diminished strength and modified form in the young king of Spain. This is a remarkable instance of the force of heredity in perpetuating a physical trait, and has been thought to be an instance of prepotency, the male line being able to transmit a deeply rooted peculiarity, the features from the maternal side having no influence in counteracting it.

As an example of prepotency, the Hapsburg lip was cited by Darwin.† To quote his words:

> It would appear that in certain families some one ancestor and after him others in the same family must have had great power in transmitting their likeness through the male line; for we cannot otherwise understand how the same features should so often be transmitted after marriage with various females as has been the case with the Austrian Emperors.

The same idea is expressed by Strahan, 'Marriage and Disease,' p. 64. As a matter of fact this feature, the big lip, was maintained and transmitted in no more remarkable way than the neurosis was, and for the same reason, namely, intermarriages in their own family, and time and time again the selection of those who exhibited the feature rather than those who did not.

In almost every generation there were some who showed the peculiar lip and there were always some who did not inherit it in any degree at all, and this is also paralleled by the mental abnormality. Therefore since there was an increasing number in each successive generation who were free from the peculiarity, the average of all descendants in each generation would give a diminution of the quality in question, and we have no prepotency at all, but merely

* Coxe, 'Austria,' I., p. 297.

† Darwin, 'Animals and Plants,' II., p. 65.

CHARLES VI.

ELIZABETH LOUISA.

ELIZABETH FARNESE.

DON CARLOS.

what we might expect were the features transmitted in the same way as the mental and moral qualities.

The following is a list in each generation of those who exhibited this peculiarity. A study of the charts of descent shows that these were the ones who were repeatedly chosen as the progenitors of the following generations. At the same time there were at least as many more whose lips were in no way peculiar, but these were almost never the ones selected to become direct ancestors of the ruling houses of Austria, Spain and France. They are graded in the following classes: slight, somewhat marked and very marked. The ones whose pictures are shown are marked with an asterisk.

First generation:	
Cymburga—died in the early part of the Fifteenth century.	
Third generation:	
Maximilian I., Emperor, 1459–1519.	
Fifth generation:	
* Charles V., Emperor, 1500–1558,	Considerable.
* Ferdinand I., Austria, 1503–1564.	Considerable.
* Mary, Queen of Hungary, 1501–1558,	Considerable.
Sixth generation:	
Philip II., Spain, 1527–1598,	Marked.
* Maximilian II., Austria,	Marked.
* Maria, daughter of Ferdinand I.,	Slight.
* Maria, daughter of Charles V.,	Very marked.
Seventh generation:	
* Philip III., Spain, 1578–1621,	Somewhat.
Marguerite, wife of Philip III.,	Marked.
* Ferdinand II., Austria,	Marked.
Marie de Medici, wife of Henri IV. of France,	Marked.
(Cosimo de Medici, her ancestor, also had a large lower lip.)	
* Albert, son of Maximilian II.,	Considerable.
Eighth generation:	
Philip IV., Spain, 1605–1665,	Very marked.
* Ferdinand III., Austria,	Slight.
* Louis XIII., France,	Marked.
Charles, son of Philip III.,	Somewhat.
Ninth generation:	
* Leopold I., Austria, 1640–1705,	Extremely marked.
* Charles II., Spain,	Marked.
Anne of Austria, wife of Louis IV.,	Somewhat.
Charles II. of England,	Marked.
Tenth generation:	
Joseph I., Austria,	Slight.
* Charles VI., Austria,	Marked.
Eleventh generation:	
Maria Theresa, Austria, 1717–1780,	Slight.

Louis, Duke of Burgundy, father of Louis XV.,	Slight.
Twelfth generation:	
Louis XV., France, 1710–1774,	Somewhat.
Don Philip of Parma, son of Philip V. of Spain,	Somewhat.
* Charles III. of Spain,	Marked.
* Elizabeth Farnese, wife of Philip V. of Spain,	Marked.
Ferdinand VI. of Spain, 1713–1759,	Somewhat.
Joseph II., Austria,	Slight.
Leopold II., Austria,	Slight.
Thirteenth generation:	
Maria Louisa, wife of Charles IV., Spain,	Slight.
* Elizabeth Louisa, daughter of Louis XV., and wife of Philip, Duke of Parma,	Marked.
Fourteenth generation:	
Ferdinand VII., Spain, 1784–1833,	Slight.
Louis XVI., France,	Slight.
Charles X., France,	Somewhat.
* Don Carlos, first pretender, son of Charles IV. of Spain,	Marked.
Sixteenth generation:	
Francis d'Assio, king of Spain,	Slight.
Eighteenth generation:	
Alfonso XIII., present king of Spain,	Somewhat.

Thus we see a tangible physical trait, avowedly due to heredity, obeying the same principle as the mental and moral qualities, tending on the whole to become eliminated as time goes on, since the entire number in each successive generation was certainly increased, while the proportionate amount of its appearance is less and less, still skipping about, however, and occasionally reappearing with almost equal force in those who inherited it at all.

I have examined the portraits of some three hundred other members of the royal families and find the same principles evident—that one sees strong general facial resemblance usually only among the closely related—but that striking peculiarities may jump a generation or two, and then reappear in some of the descendants. Also one sees that general blends are not common, but that each child tends to 'favor' one or the other of its parents or more rarely a distant ancestor.

A NEW THEORY OF LIGHT AND COLOURS.*

By Sir ISAAC NEWTON.

SIR,—To perform my late promise to you, I shall without further ceremony acquaint you, that in the beginning of the year 1666 (at which time I applied myself to the grinding of optic glasses of other figures than spherical,) I procured a triangular glass prism, to try therewith the celebrated phænomena of colours. And for that purpose having darkened my chamber, and made a small hole in my window shuts, to let in a convenient quantity of the sun's light, I placed my prism at his entrance, that it might be thereby refracted to the opposite wall. It was at first a very pleasing diversion to view the vivid and intense colours produced thereby; but after a while applying myself to consider them more circumspectly, I was surprised to see them in an oblong form; which according to the received laws of refraction, I expected would have been circular. They were terminated at the sides with strait lines, but at the ends, the decay of light was so gradual, that it was difficult to determine justly what was their figure; yet they seemed semicircular.

Comparing the length of this coloured spectrum with its breadth, I found it about five times greater; a disproportion so extravagant, that it excited me to a more than ordinary curiosity of examining from whence it might proceed. I could scarce think, that the various thickness of the glass, or the termination with shadow or darkness, could have any influence on light to produce such an effect; yet I thought it not amiss, first to examine those circumstances, and so tried what would happen by transmitting light through parts of the glass of divers thicknesses, or through holes in the window of divers sizes, or by setting the prism without, so that the light might pass through it, and be refracted before it was terminated by the hole: but I found none of those circumstances material. The fashion of the colours was in all these cases the same.

Then I suspected, whether by any unevenness in the glass, or other contingent irregularity, these colours might be thus dilated. And to try this, I took another prism like the former, and so placed it, that the light passing through them both, might be refracted con-

* This letter communicated to the editor of the transactions of the Royal Society on February 6, 1672, contains the first statement of Newton's discovery of the different colors and refrangibility of the rays of light.

trary ways, and so by the latter returned into that course from which the former had diverted it. For, by this means, I thought the regular effects of the first prism would be destroyed by the second, but the irregular ones more augmented, by the multiplicity of refractions. The event was, that the light, which by the first prism was diffused into an oblong form, was by the second reduced into an orbicular one, with as much regularity as when it did not at all pass through them. So that, whatever was the cause of that length, it was not any contingent irregularity.

I then proceeded to examine more critically, what might be effected by the difference of the incidence of rays coming from divers parts of the sun; and to that end measured the several lines and angles, belonging to the image. Its distance from the hole or prism was 22 feet; its utmost length 13¼ inches; its breadth 2⅝; the diameter of the hole ¼ of an inch; the angle, which the rays, tending towards the middle of the image, made with those lines in which they would have proceeded without refraction, was 44° 56′. And the vertical angle of the prism, 63° 12′. Also the refractions on both sides the prism, that is, of the incident and emergent rays, were as near as I could make them equal, and consequently about 54° 4′. And the rays fell perpendicularly upon the wall. Now subducting the diameter of the hole from the length and breadth of the image, there remains 13 inches the length, and 2⅜ the breadth, comprehended by those rays, which passed through the centre of the said hole, and consequently the angle of the hole, which that breadth subtended, was about 31′, answerable to the sun's diameter; but the angle which its length subtended, was more then five such diameters, namely 2° 49′.

Having made these observations, I first computed from them the refractive power of that glass, and found it measured by the ratio of the sines, 20 to 31. And then, by that ratio, I computed the refractions of two rays flowing from opposite parts of the sun's discus, so as to differ 31′ in their obliquity of incidence, and found that the emergent rays should have comprehended an angle of about 31′, as they did, before they were incident. But because this computation was founded on the hypothesis of the proportionality of the sines of incidence and refraction, which though, by my own experience, I could not imagine to be so erroneous as to make that angle but 31′, which in reality was 2° 49′; yet my curiosity caused me again to take my prism. And having placed it at my window, as before, I observed, that by turning it a little about its axis to and fro, so as to vary its obliquity to the light, more than an angle of 4 or 5 degrees, the colours were not thereby sensibly translated from their place on the wall, and consequently by that variation of incidence, the quantity of refraction was not sensibly varied. By this experiment therefore, as well as

by the former computation, it was evident, that the difference of the incidence of rays, flowing from divers parts of the sun, could not make them, after a decussation, diverge at a sensibly greater angle, than that at which they before converged; which being at most but about 31 or 32 minutes, there still remained some other cause to be found out, from whence it could be 2° 49′.

Then I began to suspect whether the rays, after their trajection through the prism, did not move in curve lines, and according to their more or less curvity tend to divers parts of the wall. And it increased my suspicion, when I remembered that I had often seen a tennis ball, struck with an oblique racket, describe such a curve line. For, a circular as well as a progressive motion being communicated to it by that stroke, its parts on that side, where the motions conspire, must press and beat the contiguous air more violently than on the other, and there excite a reluctancy and reaction of the air proportionably greater. And for the same reason, if the rays of light should possibly be globular bodies, and by their oblique passage out of one medium into another acquire a circulating motion, they ought to feel the greater resistance from the ambient æther, on that side where the motions conspire, and thence be continually bowed to the other. But notwithstanding this plausible ground of suspicion, when I came to examine it, I could observe no such curvity in them. And besides (which was enough for my purpose) I observed, that the difference between the length of the image and diameter of the hole, through which the light was transmitted, was proportionable to their distance.

The gradual removal of these suspicions, at length led me to the experimentum crucis, which was this: I took two boards, and placed one of them close behind the prism at the window, so that the light might pass through a small hole, made in it for the purpose, and fall on the other board, which I placed at about 12 feet distance, having first made a small hole in it also, for some of that incident light to pass through. Then I placed another prism behind this second board, so that the light trajected through both the boards, might pass through that also, and be again refracted before it arrived at the wall. This done, I took the first prism in my hand, and turned it to and fro slowly about its axis, so much as to make the several parts of the image, cast on the second board, successively pass through the hole in it, that I might observe to what places on the wall the second prism would refract them. And I saw, by the variation of those places, that the light tending to that end of the image, towards which the refraction of the first prism was made, did in the second prism suffer a refraction considerably greater then the light tending to the other end. And so the true cause of the length of that image

was detected to be no other, than that light consists of rays differently refrangible, which, without any respect to a difference in their incidence, were according to their degrees of refrangibility, transmitted towards divers parts of the wall.

When I understood this, I left off my aforesaid glass works, for I saw, that the perfection of telescopes was hitherto limited, not so much for want of glasses truly figured according to the prescriptions of optic authors, (which all men have hitherto imagined,) as because that light itself is a heterogeneous mixture of differently refrangible rays. So that, were a glass so exactly figured, as to collect any one sort of rays into one point, it could not collect those also into the same point, which having the same incidence upon the same medium are apt to suffer a different refraction. Nay, I wondered, that seeing the difference of refrangibility was so great, as I found it, telescopes should arrive to that perfection they are now at. For measuring the refractions in one of my prisms, I found that supposing the common sine of incidence upon one of its planes was 44 parts, the sine of refraction of the utmost rays on the red end of the colours, made out of the glass into the air, would be 68 parts, and the sine of refraction of the utmost rays on the other end 69 parts: so that the difference is about a 24th or 25th part of the whole refraction; and consequently, the object glass of any telescope cannot collect all the rays which come from one point of an object, so as to make them convene at its focus in less room than in a circular space, whose diameter is the 50th part of the diameter of its aperture; which is an irregularity, some hundreds of times greater than a circularly figured lens, of so small a section as the object glasses of long telescopes are, would cause by the unfitness of its figure, were light uniform.

This made me take reflections into consideration, and finding them regular, so that the angle of reflection of all sorts of rays was equal to their angle of incidence; I understood that by their mediation optic instruments might be brought to any degree of perfection imaginable, provided a reflecting substance could be found, which would polish as finely as glass, and reflect as much light as glass transmits, and the art of communicating to it a parabolic figure be also attained. But there seemed very great difficulties, and I have almost thought them insuperable, when I further considered, that every irregularity in a reflecting superficies makes the rays stay five or six times more out of their due course, than the like irregularities in a refracting one: so that a much greater curiosity would be here requisite, than in figuring glasses for refraction.

Amidst these thoughts I was forced from Cambridge by the intervening plague, and it was more then two years before I proceeded further. But then having thought on a tender way of polishing,

proper for metal, whereby as I imagined, the figure also would be corrected to the last; I began to try what might be effected in this kind, and by degrees so far perfected an instrument (in the essential parts of it like that I sent to London,) by which I could discern Jupiter's four concomitants, and showed them divers times to two others of my acquaintance. I could also discern the moon-like phase of Venus, but not very distinctly, nor without some niceness in disposing the instrument.

From that time I was interrupted till this last autumn, when I made the other. And as that was sensibly better then the first (especially for day objects,) so I doubt not, but they will be still brought to a much greater perfection by their endeavours, who, as you inform me, are taking care about it at London.

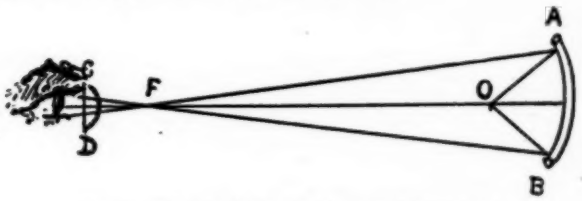


FIG. 1. [FIGURE 13, PLATE 14, IN THE ORIGINAL.]

I have sometimes thought to make a microscope, which in like manner should have, instead of an object glass, a reflecting piece of metal. And this I hope they will also take into consideration. For those instruments seem as capable of improvement as telescopes, and perhaps more, because but one reflective piece of metal is requisite in them, as you may perceive by the diagram, (fig. 13, pl. 14,) where AB represents the object metal, CD the eye glass, F their common focus, and O the other focus of the metal, in which the object is placed.

But to return from this digression, I told you, that light is not similar, or homogeneal, but consists of difform rays, some of which are more refrangible than others: so that of those, which are alike incident on the same medium, some shall be more refracted than others, and that not by any virtue of the glass, or other external cause, but from a predisposition, which every particular ray has to suffer a particular degree of refraction.

I shall now proceed to acquaint you with another more notable difformity in its rays, wherein the origin of colours is unfolded: concerning which I shall lay down the doctrine first, and then, for its examination, give you an instance or two of the experiments, as a specimen of the rest.—The doctrine you will find comprehended and illustrated in the following propositions:—

1. As the rays of light differ in degrees of refrangibility, so they also differ in their disposition to exhibit this or that particular colour. Colours are not qualifications of light, derived from refractions, or reflections of natural bodies (as it is generally believed,) but original and connate properties, which in divers rays are diverse. Some rays are disposed to exhibit a red colour, and no other; some a yellow, and no other; some a green, and no other, and so of the rest. Nor are there only rays proper and particular to the more eminent colours, but even to all their intermediate gradations.

2. To the same degree of refrangibility ever belongs the same colour, and to the same colour ever belongs the same degree of refrangibility. The least refrangible rays are all disposed to exhibit a red colour, and contrarily, those rays which are disposed to exhibit a red colour, are all the least refrangible: so the most refrangible rays are all disposed to exhibit a deep violet-colour, and contrarily, those which are apt to exhibit such a violet colour, are all the most refrangible. And so to all the intermediate colours, in a continued series, belong intermediate degrees of refrangibility. And this analogy betwixt colours, and refrangibility, is very precise and strict; the rays always either exactly agreeing in both, or proportionally disagreeing in both.

3. The species of colour, and degree of refrangibility proper to any particular sort of rays, is not mutable by refraction, nor by reflection from natural bodies, nor by any other cause, that I could yet observe. When any one sort of rays has been well parted from those of other kinds, it has afterwards obstinately retained its colour, notwithstanding my utmost endeavours to change it. I have refracted it with prisms, and reflected it with bodies, which in day-light were of other colours; I have intercepted it with the coloured film of air interceding two compressed plates of glass; transmitted it through coloured mediums, and through mediums irradiated with other sorts of rays, and diversely terminated it; and yet could never produce any new colour out of it. It would, by contracting or dilating, become more brisk, or faint, and by the loss of many rays, in some cases very obscure and dark; but I could never see it change in specie.

4. Yet seeming transmutations of colours may be made, where there is any mixture of divers sorts of rays. For in such mixtures, the component colours appear not, but, by their mutual allaying each other, constitute a middling colour. And therefore, if by refraction or any other of the aforesaid causes, the difform rays, latent in such a mixture, be separated, there shall emerge colours different from the colour of the composition. Which colours are not new generated, but only made apparent by being parted; for if they be again entirely mixed and blended together, they will again compose that colour,

which they did before separation. And for the same reason, transmutations made by the convening of divers colours are not real; for when the difform rays are again severed, they will exhibit the very same colours, which they did before they entered the composition; as you see, blue and yellow powders, when finely mixed, appear to the naked eye green, and yet the colours of the component corpuscles are not thereby really transmuted, but only blended. For, when viewed with a good microscope, they still appear blue and yellow interspersedly.

5. There are therefore two sorts of colours. The one original and simple, the other compounded of these. The original or primary colours are, red, yellow, green, blue, and a violet-purple, together with orange, indigo, and an indefinite variety of intermediate gradations.

6. The same colours in specie with these primary ones may be also produced by composition: for a mixture of yellow and blue makes green; of red and yellow makes orange; of orange and yellowish green makes yellow. And in general, if any two colours be mixed, which in the series of those, generated by the prism, are not too far distant one from another, they by their mutual alloy compound that colour, which in the said series appears in the midway between them. But those which are situated at too great a distance, do not so. Orange and indigo produce not the intermediate green, nor scarlet and green the intermediate yellow.

7. But the most surprising and wonderful composition was that of whiteness. There is no one sort of rays which alone can exhibit this. It is ever compounded, and to its composition are requisite all the aforesaid primary colours, mixed in a due proportion. I have often with admiration beheld, that all the colours of the prism being made to converge, and thereby to be again mixed as they were in the light before it was incident upon the prism, reproduced light, intirely and perfectly white, and not at all sensibly differing from a direct light of the sun, unless when the glasses, I used, were not sufficiently clear; for then they would a little incline it to their colour.

8. Hence therefore it comes to pass, that whiteness is the usual colour of light; for, light is a confused aggregate of rays indued with all sorts of colours, as they are promiscuously darted from the various parts of luminous bodies. And of such a confused aggregate, as I said, is generated whiteness, if there be a due proportion of the ingredients; but if any one predominate, the light must incline to that colour; as it happens in the blue flame of brimstone; the yellow flame of a candle; and the various colours of the fixed stars.

9. These things considered, the manner how colours are produced by the prism, is evident. For, of the rays constituting the incident light, since those which differ in colour, proportionally differ in

refrangibility, they by their unequal refractions must be severed and dispersed into an oblong form in an orderly succession, from the least refracted scarlet, to the most refracted violet. And for the same reason it is that objects, when looked upon through a prism, appear coloured. For the difform rays, by their unequal refractions, are made to diverge towards several parts of the retina, and there express the images of things coloured, as in the former case they did the sun's image upon a wall. And by this inequality of refractions they become not only coloured, but also very confused and indistinct.

10. Why the colours of the rainbow appear in falling drops of rain, is also from hence evident. For, those drops which refract the rays disposed to appear purple, in greatest quantity to the spectator's eye, refract the rays of other sorts so much less, as to make them pass beside it; and such are the drops on the inside of the primary bow, and on the outside of the secondary or exterior one. So those drops, which refract in greatest plenty the rays apt to appear red, towards the spectator's eye, refract those of other sorts so much more, as to make them pass beside it; and such are the drops on the exterior part of the primary, and interior part of the secondary bow.

11. The odd phænomena of an infusion of lignum nephriticum, leaf gold, fragments of coloured glass, and some other transparently coloured bodies, appearing in one position of one colour, and of another in another, are on these grounds no longer riddles. For, those are substances apt to reflect one sort of light, and transmit another; as may be seen in a dark room, by illuminating them with similar or uncompounded light. For, then they appear of that colour only, with which they are illuminated, but yet in one position more vivid and luminous than in another, accordingly as they are disposed more or less to reflect or transmit the incident colour.

12. From hence also is manifest the reason of an unexpected experiment, which Mr. Hook, somewhere in his micrography, relates to have made with two wedge-like transparent vessels, filled the one with red, the other with a blue liquor: namely, that though they were severally transparent enough, yet both together became opaque; for, if one transmitted only red, and the other only blue, no rays could pass through both.

13. I might add more instances of this nature; but I shall conclude with this general one, that the colours of all natural bodies have no other origin than this, that they are variously qualified to reflect one sort of light in greater plenty than another. And this I have experimented in a dark room, by illuminating those bodies with uncompounded light of divers colours. For, by that means, any body may be made to appear of any colour. They have there no appropriate colour, but ever appear of the colour of the light cast upon them,

but yet with this difference, that they are most brisk and vivid in the light of their own day-light colour. Minium appears there of any colour indifferently, with which it is illustrated, but yet most luminous in red; and so bise appears indifferently of any colour with which it is illustrated, but yet most luminous in blue. And therefore minium reflects rays of any colour, but most copiously those indued with red; and consequently when illustrated with daylight, that is, with all sorts of rays promiscuously blended, those qualified with red shall abound most in the reflected light, and by their prevalence cause it to appear of that colour. And for the same reason bise, reflecting blue most copiously, shall appear blue by the excess of those rays in its reflected light; and the like of other bodies. And that this is the entire and adequate cause of their colours, is manifest, because they have no power to change or alter the colours of any sort of rays, incident apart, but put on all colours indifferently, with which they are enlightened.

These things being so, it can be no longer disputed, whether there be colours in the dark, nor whether they be the qualities of the objects we see, no nor perhaps whether light be a body. For since colours are the qualities of light, having its rays for their entire and immediate subject, how can we think those rays qualities also, unless one quality may be the subject of and sustain another; which in effect is to call it substance. We should not know bodies for substances, were it not for their sensible qualities, and the principal of those being now found due to something else, we have as good reason to believe that to be a substance also.

Besides, whoever thought any quality to be a heterogeneous aggregate, such as light is discovered to be. But, to determine more absolutely what light is, after what manner refracted, and by what modes or actions it produces in our minds the phantasms of colours, is not so easy. And I shall not mingle conjectures with certainties.

Reviewing what I have written, I see the discourse itself will lead to diverse experiments sufficient for its examination, and therefore I shall not trouble you further, than to describe one of those which I have already insinuated.

In a darkened room make a hole in the shut of a window, whose diameter may conveniently be about a third part of an inch, to admit a convenient quantity of the sun's light; and there place a clear and colourless prism, to refract the entering light towards the further part of the room, which, as I said, will thereby be diffused into an oblong coloured image. Then place a lens of about three feet radius (suppose a broad object glass of a three-foot telescope,) at the distance of about four or five feet from thence, through which all those colours may at once be transmitted, and made by its refraction to convene

at a further distance of about ten or twelve feet. If at that distance you intercept this light with a sheet of white paper, you will see the colours converted into whiteness again by being mingled. But it is requisite, that the prism and lens be placed steady, and that the paper on which the colours are cast be moved to and fro; for by such motion, you will not only find at what distance the whiteness is most perfect, but also see how the colours gradually convene, and vanish into whiteness, and afterwards having crossed one another in that place where they compound whiteness, are again dissipated and severed, and in an inverted order retain the same colours which they had before they entered the composition. You may also see, that if any of the colours at the lens be intercepted, the whiteness will be changed into the other colours. And therefore that the composition of whiteness be perfect, care must be taken that none of the colours fall beside the lens.

In the annexed design of this experiment, ABC expresses the prism set endwise to sight, fig. 14, pl. 14, close by the hole F of the window EG. Its vertical angle ACB may conveniently be about 60 degrees: MN designs the lens. Its breadth 2½ or 3 inches. SF one of the straight lines, in which difform rays may be conceived to flow successively from the sun. FP and FR two of those rays unequally refracted, which the lens makes to converge towards Q, and after decussation to diverge again. And HI the paper, at divers distances, on which the colours are projected; which in Q constitute whiteness, but are red and yellow in R, *r*, and *ρ*, and blue and purple in P, *p*, and *π*.

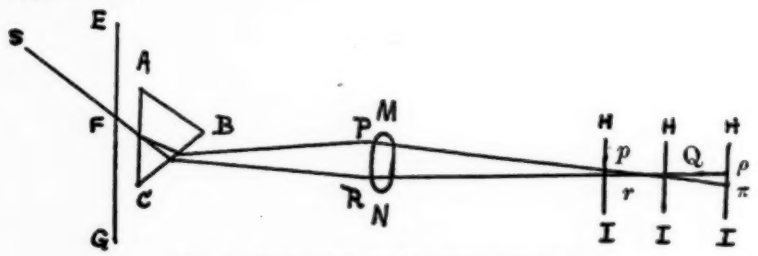


FIG. 2. FIGURE 14, PLATE 14, OF THE ORIGINAL.

If you proceed further to try the impossibility of changing any uncompounded colour, (which I have asserted in the 3d and 13th propositions) it is requisite that the room be made very dark, least any scattering light mixing with the colour disturb and allay it, and render it compound, contrary to the design of the experiment. It is also requisite, that there be a perfecter separation of the colours than, after the manner above described, can be made by the refraction of one single prism, and how to make such further separations, will scarcely be difficult to them that consider the discovered laws of re-

fractions. But if trial shall be made with colours not thoroughly separated, there must be allowed changes proportionable to the mixture. Thus, if compound yellow light fall upon blue bise, the bise will not appear perfectly yellow but rather green, because there are in the yellow mixture many rays indued with green, and green being less remote from the usual blue colour of bise than yellow, is the more copiously reflected by it.

In like manner, if any one of the prismatic colours, suppose red, be intercepted, on design to try the asserted impossibility of reproducing that colour out of the others which are pretermitted; it is necessary, either that the colours be very well parted before the red be intercepted, or that together with the red the neighbouring colours, into which any red is secretly dispersed, (that is, the yellow, and perhaps green too) be intercepted, or else, that allowance be made for the emerging of so much red out of the yellow green, as may possibly have been diffused, and scatteringly blended in those colours. And if these things be observed, the new production of red, or any intercepted colour will be found impossible.

This I conceive is enough for an introduction to experiments of this kind; which if any of the Royal Society shall be so curious as to prosecute, I should be very glad to be informed with what success; that, if anything seem to be defective, or to thwart this relation, I may have an opportunity of giving further direction about it, or of acknowledging my errors, if I have committed any.

DISCUSSION AND CORRESPONDENCE.

ARE FELLOWSHIPS ALMSGIVING OR INVESTMENTS?

To the Editor:—In his admirable article, 'University Building,' in the August number of THE POPULAR SCIENCE MONTHLY, President Jordan has made some assertions that seem in a measure contradictory, and which may tend to retard the very spirit of research which he so heartily commends.

He says: "The whole system of fellowships for advanced students is on trial, with most of the evidence against it. The students paid to study are not the ones who do the work. When they are such they would have done the work unpaid. The fellowship system tends to turn science into almsgiving, to make the promising youth feel that the world owes him a living." Mr. Carnegie's gift of $10,000,000, for the promotion of research work, will scarcely engender a spirit of pauperism among scientists who are enabled by this means to carry on more extended investigations. On the contrary what a thrill of enthusiasm flashed round the world when the announcement of the gift was made! What a stimulus to the prosecution of advanced work was the recognition of the need of opportunity to work!

Let us contrast the following statements, which occur in the last paragraph of the article, with what has been already quoted: "As men of science are needed, they cannot make themselves. Those with power can help them. This fact has given the impulse to the far reaching gifts of Stanford, Rockefeller, Carnegie and Rhodes. These are not gifts but investments, put to the credit of the country's future. The people too have power. The same feeling of investment has led them to build their state universities and to entrust to them not only the work of personal culture but of advancement in literature, science and arts."

If Dr. Jordan regards the fellowship system as a kind of almsgiving, bestowed needlessly, and as developing undue arrogance in the promising student, how can he commend the acceptance of the munificent gifts of Stanford, Rockefeller and Rhodes? Is not the bestowal of a fellowship likewise an investment which stimulates and helps the individual, just as the larger gifts help the whole people?

MRS. W. A. KELLERMAN.

COLUMBUS, OHIO.

THE PROGRESS OF SCIENCE.

THE CARNEGIE INSTITUTION AND THE MARINE BIOLOGICAL LABORATORY.

THE first information made public in regard to the policy of the Carnegie Institution, beyond the original outline presented by Mr. Carnegie in his deed of gift and some very general statements made by President Gilman and other members of the executive committee, is the announcement that the corporation of the Marine Biological Laboratory at Woods Hole has voted to transfer its buildings and equipment to the trustees of the Carnegie Institution. This gift can not be accepted until the trustees hold their November meeting, but it was stated to the corporation of the laboratory that the executive committee of the Carnegie Institution would recommend that the laboratory be made a branch of the institution and liberally developed, money being appropriated for buildings and $20,000 a year for current expenses. It is rumored further that a geophysical laboratory will be established at Washington and supported on a large scale.

The Carnegie Institution, the Woods Hole Laboratory and science in America are face to face with complicated circumstances, and difficult problems are involved in any solution. The institution can contribute greatly to the development of science either by establishing and conducting several great laboratories or by cooperating with existing agencies. The majority of American men of science prefer the latter course and will regret the apparent decision of the executive committee to recommend the acquisition of a biological laboratory. It may be said that the various scientific and educational institutions throughout the country and their officers are selfish, hoping to share in the distribution of funds or fearing a new rival. It has, however, also been suggested that the officers of the Carnegie Institution may aggrandize the institution rather than contribute in the most effective manner to scientific research. We, however, believe that both the officers of the institution and the scientific men of the country are entirely sincere in their efforts to make the Carnegie Institution the most potent factor possible for the advancement of science. The executive committee of the institution has appointed advisory committees of men of science in different subjects, and these committees are securing evidence and preparing reports. It is perhaps proper that these reports and even the names of the members of the committees should be kept secret until the executive committee has made its report to the trustees. We hope, however, that the trustees will not commit the institution to any irrevocable policy in November, but will make public all the alternative suggestions presented and permit careful consideration and full discussion before final plans are adopted.

Whether or not it is advisable for the Carnegie Institution to conduct a marine biological laboratory rather than cooperate with the Fish Commission and the various existing laboratories may be an open question, but it is undoubtedly true that most of those interested in the Woods Hole laboratory regret that it has been found necessary to turn it over to the Carnegie Institution. The Woods Hole laboratory is the only institution of national importance that has been conducted by

scientific men. The present organization of the laboratory is a corporation, composed of those interested in the research work of the laboratory, which elects trustees, chiefly biologists representing different universities. This democratic form of government must surely be the ideal of scientific men. They may endure the usual board of trustees composed of men of affairs who delegate authority to a president; they may even realize the business efficiency of such an organization; but they look forward to the time when they will choose their own leaders and define their own policy. The laboratory at Woods Hole has illustrated both the strength and weakness of a democratic organization. There has been friction in the management, and the finances have never been in a satisfactory condition. On the other hand, there has been enthusiasm, self-sacrifice and a high ideal of research. If the Woods Hole laboratory is directed from Washington it will go forward with the efficiency of the scientific departments of the government, and will be practically one of these, being for all essential purposes coordinate with the Fish Commission or the Geological Survey, but with scarcely one fiftieth of the income. There will not, however, be found a director who will devote himself to the service of the laboratory without dreaming of receiving a dollar's salary, or men of science ready to give freely the time and money of which they have so little to spare. Those connected with the laboratory will no longer seek to give what they can, but rather to get what they can, and the whole spirit of the place will change.

Just for a handful of silver he left us,
  Just for a riband to stick in his coat—
Found the one gift of which fortune bereft us,
  Lost all the others she lets us devote;
They, with the gold to give, doled him out silver,
  So much was theirs who so little allowed:
How all our copper had gone for his service!

SCIENCE IN AMERICAN JOURNALS.

THE fact that the *Forum* and the *International Monthly*, both of which include science in their scope, have abandoned monthly publication and will hereafter appear but four times a year is somewhat disquieting; it seems to indicate that journals maintaining a high standard are not well supported in this country. We have left only the *North American Review* and THE POPULAR SCIENCE MONTHLY, in addition to the monthlies that depend chiefly on politics, fiction or literary gossip. The *North American Review* has at times tended to rely more on the names signed to its articles than on their contents, and must on the whole be regarded as a political rather than as a literary journal. THE POPULAR SCIENCE MONTHLY has a limited and definite field, for which it is urgently needed and in which it is adequately supported; but the larger part of its contents can not be regarded as literature. We keep within the limits of obvious truth in stating that this journal in its special field has set a standard for other nations which they have not yet met. The same is true of our illustrated monthlies which reflect all degrees of taste and refinement. They have carried mechanical illustration and the short story to a singular point of perfection. But it can not be claimed that photo-engraving and the short story are the highest forms of art. The editor of one of our most prosperous monthlies has recently stated that a magazine should never contain any thing that could as well have been published the month before. The requirements of true literature are the reverse; nothing is literature that could not as well be published a year hence. The magazine seems likely to devour its own offspring, for while there come forward many new writers of short stories, but few survive. A month's life does not encourage a writer to do his best work, and we have in

fact no short stories such as those of Hawthorne and Poe. Weekly journals of literature have also declined. *The Critic* could not continue as a weekly and *The Nation* has become a compilation from the *Evening Post*.

Corresponding with the wide diffusion of physical comfort in a democracy we have an abundant supply of Sunday newspapers, illustrated magazines and current novels. These are well adapted to the readers for whom they are manufactured and demonstrate a degree and extension of intelligence which is all that could be expected, and is on the whole highly satisfactory. But there appears to be no intellectual development corresponding with the large fortunes accumulated by our captains or knights—as the case may be—of industry. As far as journals and reviews are concerned, we must frankly admit our inferiority to Great Britain and France. This does not, however, mean that we should or shall remain quietly or permanently in this position.

We are here especially concerned with science; but we do not admit that science and literature can be divorced. Science supplies to literature both method and subject matter, whereas clear and correct expression is essential to science. There are a few American men of science who have admirable command of the language they write, but the men with exceptional powers of expression are rarer and the average is lower than in France or in Great Britain. The treatment of science in the newspapers and magazines is also less satisfactory here than abroad. Articles of excellent quality are often published, but fads and charlatanism are exploited with equal apparent authority, and the reader must become entirely bewildered, having no means of discriminating one alleged scientific article from another, and the entire scientific miscellany is given about the same attention and credence as the columns devoted to the gossip from Saratoga. Some newspapers and magazines are better than others, but there appears not to be a single one of them that submits its scientific contributions to an expert. Hence while the literary taste of the community is mediocre, its scientific sense is practically nonexistent.

A GRADUATE SCHOOL OF AGRICULTURE.

THE Graduate School of Agriculture, which held a four weeks' session during the month of July at the Ohio State University, Columbus, Ohio, marks an important step of progress in agricultural science and education in the United States. This school was the outcome of a happy thought which came to Professor Thomas F. Hunt, dean of the College of Agriculture and Domestic Science of the Ohio State University, while he was attending the convention of the Association of American Agricultural Colleges and Experiment Stations at San Francisco in 1899. Seeing how inadequate were the opportunities at such short conventions for the discussion of anything more than the most general problems of agricultural science and education it occurred to him that it would be a good plan to establish a summer school for advanced students of agriculture at which leading teachers and investigators from the agricultural colleges and experiment stations and the United States Department of Agriculture should present in some regular way summaries of the recent progress of agricultural science, illustrate improved methods of teaching agricultural subjects and afford a somewhat extended opportunity for the discussion of live topics drawn from the rapidly advancing science of agriculture. This idea received the cordial approval of President Thompson of the Ohio State University, and on the recommendation of these two men the board of trustees of the university voted to establish such a school

and generously made provision for the financial support of its first session.

The Association of American Agricultural Colleges and Experiment Stations at its convention in 1901 favored the plan for the school and voted that, if the success of the first session seemed to justify its continuance, it be made a cooperative enterprise under the control of the association. Hon. James Wilson, Secretary of Agriculture, also expressed his cordial approval of this movement, and, on his advice, Dr. A. C. True, director of the Office of Experiment Stations, consented to act as dean and other officers of the Department of Agriculture to be members of its faculty. Under these favorable auspices there was a little difficulty in securing a strong faculty. As actually organized this included 35 men, of whom 26 are professors in agricultural colleges, 7 are leading officers of the Department of Agriculture, and 2 are officers of the New York State Experiment Stations. Courses were offered in agronomy, zootechny, dairying, and breeding of plants and animals. The school was housed in the substantial and well-equipped agricultural building of the university, where were illustrated the most approved apparatus of instruction in soil physics, dairying and other agricultural subjects. Besides the livestock of the university farm, leading breeders of Ohio furnished choice animals for the stock-judging exercises.

General problems of agricultural science and pedagogy were discussed at the inaugural exercises and at Saturday morning conferences. Among the topics thus treated were the history of agricultural education and research in the United States; the organization of agricultural education in colleges, secondary schools, nature study courses, correspondence courses, farmers' institutes and various forms of unversity extension; what constitutes a science of agriculture; educational values of courses in agriculture; methods and values of cooperative experiments. Through social assemblies, visits to typical Ohio farms, and much informal discussion wherever the students met each other, the educational influences of the school were greatly extended. Seventy-five students were in attendance. These were drawn from 28 states and territories, including such widely separated regions as Maine, Oregon, California, New Mexico and Alabama. There was one student from Canada and one from the Argentine Republic. There was also one woman, and the colored race was represented by teachers from the Tuskegee Institute and the North Carolina Agricultural College. Twenty-seven of the students are professors or assistant professors in agricultural colleges, thirty-one are assistants in the agricultural colleges and experiment stations, nine are recent college graduates, and eight are engaged in farming.

Considering the character of the faculty and students, it goes without saying that the whole period of the session was occupied with the most earnest and profitable work. Without doubt the influence of this school will be felt throughout the country in the improvement of courses of instruction in agriculture and the strengthening of the lines and methods of investigation of agricultural subjects. In other ways the school will exert a beneficial influence. So rapid has been the accumulation of materials for a real science of agriculture during the past few years that even professional students of agriculture have not realized how large a mass of knowledge is already available for molding into a systematic body of truth which may be utilized for pedagogic purposes, as well as for inductions of scientific and practical value. The summaries given by the experts gathered at this graduate school have emphasized this fact and shown in a striking manner that agricultural education and research may now be properly and efficiently organ-

ized with reference to the science of agriculture itself, rather than be, as heretofore, very largely a matter of the sciences related to agriculture. This will serve to stimulate greatly the movement already begun for the reduction of the materials of agricultural science to 'pedagogic form' for use in colleges and secondary schools, and for the reorganization of agricultural institutions of research on the basis of the divisions and subdivisions of agriculture, instead of physics, chemistry, botany and other primary and secondary sciences. The day will thus be hastened when the science of agriculture will rank with such tertiary sciences as geology, geography and medicine as one of the great systems of knowledge of direct benefit to mankind.

We are without doubt in this country just on the edge of a great popular movement for the improvement of the conditions of rural life through the improvement of the rural schools. As one phase of this movement there will come the broadening of the instruction in the principles of agriculture so that in addition to college courses we shall have secondary courses in ordinary and special high schools and even some elementary instruction in the common schools. In establishing the lines and methods of secondary and elementary instruction in agriculture so that it may be useful and attractive to the masses of our rural youth, the leaders in agricultural science gathered in the Graduate School of Agriculture this summer will play an important part, and it is believed that they have gone out from this school with much inspiration to renewed efforts in this direction. For both the thorough establishment of the science of agriculture and the wide popularization of this science the new school will, it is believed, be an efficient agency.

It is to be hoped therefore either that some other university will open its doors for a second session of the school another year, or that the Association of Agricultural Colleges and Experiment Stations will assume this burden, or that through the cooperation of the association with universities and the Department of Agriculture the Graduate School of Agriculture may become a permanent institution.

BIOGRAPHIES OF EMINENT CHEMISTS.

AUGUST WILHELM VON HOFMANN is the subject of a biography published on the 8th of April, 1902, as an extra number of the Reports of the German Chemical Society, that date being the 84th anniversary of the birth of the distinguished chemist. It was begun by Dr. Tiemann, for many years Hofmann's assistant, but after his untimely death it was completed by Emil Fischer and Jacob Volhard, assisted by others, all of whom had been pupils of the energetic master. Of Hofmann's career several sketches have already been published, as 'Memorial Lectures of the Chemical Society [of London],' read May 5, 1893, the first anniversary of his death; these were 'Personal Reminiscences' by Lord Playfair, as well as by Sir Frederick Abel, and the 'Origin of the Coal-Tar Industry,' by Dr. Perkin, and 'The Scientific Work of Hofmann' by Professor Armstrong. Notwithstanding these valuable contributions to the subject by English contemporaries and fellow-workers, the biography issued by the German Chemical Society will long be the standard. It portrays more in detail Hofmann's strong personality, his relations to society especially during his long residence in London, his pleasure travel with agreeable souvenirs of the visit to the United States in 1883, and narrates anecdotes illustrating his genial disposition and humor; at the same time the volume does not neglect summarizing his fruitful chemical researches carried on through a period of more than fifty years with never-dying industry and enthusiasm. The

number and variety of the discoveries made in the laboratory by Hofmann but faintly reflect his truly extraordinary capacity for hard work; even after passing his seventieth birthday he occasionally worked in the laboratory until two or three o'clock in the morning.

One of Hofmann's most valuable series of investigations was his study of coal-tar derivatives; begun in 1845 it reached a lofty point in 1858 and culminated in the discovery of a long line of magnificent dyes whose hues and names have become household words; it is true that all aniline colors are not Hofmann's own, but he worked out the fundamental principles governing their existence, and pointed out the way for their creation by the labors of his pupils and others. Hofmann was an energetic and agreeable lecturer to classes in the university and he excelled in devising original and brilliant experiments for illustrating these lectures; some of these he made known through his 'Introduction to Modern Chemistry,' published in 1865, and in articles contributed to the *Berichte* in succeeding years (1871–1882). Hofmann was married four times and had eleven children born to him, eight of whom survive him. The biography is illustrated by two portraits of the eminent chemist, one representing him in the twenty-eighth year, and the other in the seventy-third year of age.

It is rather singular and hardly creditable to French authors that no adequate biography of the centenarian chemist, Michel Eugène Chevreul, has as yet appeared. Chevreul was born August 31, 1786, and on the occasion of his hundredth birthday he was presented with a gold medal, with ceremonies that included addresses from men of distinction. An account of this function was published at Rouen, in 1886, illustrated by an engraved portrait of the veteran chemist and with a facsimile of the medal. In the same year there appeared at Paris a full catalogue of Chevreul's contributions to science, numbering 547 different articles and extending from 1806 to 1886. This is, however, incomplete, for Chevreul did not die until April 9, 1889, and his literary activity continued to the end. Chevreul's 'Researches on Fats' (1823) forms the starting point of one of our great industries and his essay on 'Colors—their Application to Industrial Arts,' has borne valuable fruit. An obituary of Chevreul by A. W. von Hofmann appeared in the Reports of the German Chemical Society in 1889.

One of the greatest benefactions conferred on mankind by modern science was the method of manufacturing common soda invented by Nicolas Leblanc. The biography of this little appreciated and poorly rewarded chemist was published in 1884 by his grandson, Auguste Anastass.

After the outbreak of the Revolution in France the industrial needs of the country became more and more pressing, the Academy of Sciences offered a prize of 12,000 *livres* for a practical method of manufacturing carbonate of soda from common salt; this problem attracted the attention of a modest physician devoted to chemical studies, Nicolas Leblanc. The history of his chemical success, and his practical misfortunes, his financial distress, and his shocking death by his own hand make very sad reading; this tragic event occurred in 1806.

An appendix to this biography has also a sad interest; it is an inventory of the apparatus and chemicals contained in the laboratory of Lavoisier, made five months after his execution, and signed by Nicolas Leblanc.

Henry Morton, who died May 9, 1902, will be best remembered as a physicist, but he began his scientific career as a professor of chemistry. An artistic and beautifully illustrated 'Biographical Notice of Dr. Morton' forms a volume prepared by his friends, Coleman Sellers and Albert R.

Leeds, and printed for private circulation in 1892; this portrays his career as an exceedingly versatile man endowed by nature with the gifts of artist, poet, linguist and inventive ability, as well as those attributes which caused him to become widely known as a successful scientist. One of Dr. Morton's intellectual feats deserves recording; while still a college undergraduate he translated and designed an artistic monograph on the Rosetta Stone, which was afterwards reproduced by lithography in all its gay colors. His contributions to science are briefly narrated; his success in filling the responsible position of president of the Stevens Institute of Technology for many years, and his great generosity to the same, will require another volume yet to be written.

THE COMPARATIVE GROWTH OF BACTERIA IN MILK.

At the last meeting of the American Society of Bacteriologists Professor H. W. Conn described a series of experiments, the design of which was to determine what species of bacteria develop in milk during the first twenty-four hours and what species disappear. The general purpose of the experiments was to determine as far as possible the relation of milk bacteria to the healthfulness of milk. The conclusions presented by the paper were as follows: (1) Milk freshly drawn from the cow contains a large variety of bacteria. (2) For the first six hours and sometimes more, there is no increase in the number of bacteria, even when the milk is kept at 70°. On the contrary, there is commonly a decrease due to what has been called the 'germicide power' of milk. (3) In the fresh milk the largest number of bacteria are streptococci, which come, in most cases, directly from the udder of the cow. (4) During the first forty-eight hours there is a very great increase in the number of bacteria, but the number present after one or two days' growth is quite independent of the number present at the start. In many cases milk, which when fresh contained a small number of bacteria, at the end of forty-eight hours contained a number far greater than other samples of milk which at the outset had a larger number of bacteria present. (5) During the first forty-eight hours there is a considerable increase in the number of streptococci, followed by their decrease and final disappearance. (6) At the outset the number of lactic bacteria is extremely small, so small as, at times, quite to escape observation. (7) These lactic bacteria are, at least in the series of experiments described, derived from sources external to the cow and never, or rarely, from the milk ducts. (8) The lactic bacteria, though very few in number at the outset, increase far more rapidly than any other types, so that within twenty-four hours they are commonly in the majority, and by the end of forty-eight hours they commonly comprise considerably over ninety per cent. of all the bacteria present.

SCIENTIFIC ITEMS.

Dr. Charles Kendall Adams died at Redlands, Cal., on July 27. He was president of Cornell University from 1885 to 1892, when he resigned and became president of the University of Wisconsin. This post he held actively until 1901, when he retired on account of ill health.

President David Starr Jordan has been successful in securing a valuable collection of fishes in the Bay of Apia, Samoa, some four hundred and fifty species, many of them new, having been collected.—Gen. A. W. Greely, chief of the U. S. Signal Service, has returned from Alaska, where he had been inspecting the work on the Government telegraph line from Valdez to Eagle City.—Mr. F. H. Newell, chief hydrographer of the U. S. Geological Survey, has gone to the West to supervise in

connection with the work in irrigation authorized by Congress. Surveying parties are in the field in California, Oregon, Washington, Montana, Utah, Nevada, Idaho, Arizona and Colorado.

A STATUE of Pasteur was unveiled at his birthplace, Dôle, Jura, on August 3.—The centenary of the death of Bichat, the celebrated anatomist and physiologist, was commemorated on July 22, under the auspices of the French Society of the History of Medicine.—The centenary of the birth of the Norwegian mathematician, Niels Henrik Abel, will be celebrated at Christiania in September. Abel was born in 1802 and died at the early age of twenty-seven years, but in this short period attained rank among the foremost mathematicians of the century.—A memorial to John Fitch, who is said to have been the first to apply steam to the running of a boat, has been erected in Warminster, Pa. It bears the inscription: "John Fitch here conceived the idea of the first steamboat. He ran a boat with side-wheels by steam on a pond below Davisville in 1785. Bucks County Historical Society."—A bronze tablet has been unveiled at Lafayette College in memory of the late James H. Coffin. The inscription reads as follows: "In memory of James Henry Coffin, LL.D. Long a main-stay of Lafayette College, professor of mathematics, natural philosophy and astronomy, 1846–1873; vice-president and college treasurer, 1863–1873. A tireless teacher and administrator, an officer of the church, a friend of the slave. A member of the National Academy of Sciences, author of 'Winds of the Globe.' He annexed the atmosphere to the realm of science, and searched the highways of the winds and the paths of vagrant storms. Born in Williamsburg, Mass., September 6, 1806; died in Easton, February 6, 1873. The class of 1866 has erected this tablet."

PROFESSOR W. E. RITTER, of the University of California, has secured funds for the erection of a marine laboratory at San Pedro, which will be used as a center for the biological study of the Pacific coast.—Mr. W. H. Evans, of the office of Experiment Stations, U. S. Department of Agriculture, has returned from Porto Rico, where he was in conference with Mr. F. D. Gardner, in charge of the Porto Rico Station, with reference to the selection of a permanent site and the development of the station there.—The French Minister of Agriculture has established an office for agricultural information, the object of which is to act as a bureau of correspondence and a means of popularizing scientific agriculture.—Queensland has given up its weather bureau, and the services of Mr. C. L. Wragge and others have been dispensed with. It is hoped that an arrangement may be made by which the service will be continued by the federal government.—Mr. J. Pierpont Morgan has presented to the Museum of the Jardin des Plantes, Paris, the collection of precious stones formed by Mr. George F. Kunz for the Buffalo Exhibition.

THE Berlin Academy of Sciences has announced that its academic prize of 5,000 Marks, will be awarded in 1904 for an investigation of the kathode rays and in 1905 for an investigation of the theory of functions of several variables which admit of linear substitution. The income of the Cothenius legacy—$2,000—for 1904 will be awarded for investigations of new varieties of grain. The papers may be written in English and must be presented without the name of the author to the Bureau of the Academy, Universtät Strasse, 8, Berlin.